DOCUMENT RESUME

ED 367 305 IR 016 579

AUTHOR	Schoenmaker, Jan, Ed.; Stanchev, Ivan, Ed.
TITLE	Principles and Tools for Instructional Visualisation.
INSTITUTION	Twente Univ., Enschede (Netherlands). Faculty of Educational Science and Technology.
PUB DATE	94
NOTE	152p.
AVAILABLE FROM	Faculty of Educational Science and Technology, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands.
PUB TYPE	Collected Works - General (020) -- Books (010)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	*Computer Assisted Instruction; Computer Simulation; *Educational Research; Foreign Countries; Hypermedia; *Instructional Development; Instructional Effectiveness; *Multimedia Instruction; *Research and Development; *Visualization; Visual Learning
IDENTIFIERS	*Multimedia Materials; Twente University of Technology (Netherlands)

ABSTRACT

This report reflects research and development on visualization and the use of multimedia carried out at the Department of Applied Education, Division of Instrumental Science and Technology of the University of Twente (Netherlands) and the Andersen Consulting Educational Computing Consortium, also at the University of Twente. The report contains 11 papers organized into three main sections: (1) "Concepts in Instructional Visualisation" includes "Visualisation and Effective Instruction" (Jef Moonen), "Principles and R&D Aspects in Instructional Visualisation" (Ivan Stanchev), "Human Factors and Multi Media Design" (Lex Bergers), "Conceptual Metaphors for the Visualisation in Interactive Learning" (Piet Kommers), and "Functions and Design of Video Components in Multi-Media Applications: A Review" (Plon W. Verhagen); (2) "Design and Development of Multi Media Applications" includes "Designing Multimedia Applications" (Maud van den Meiracker), "Multimedia Development Tools" (Jan Schoenmaker and Erik Nienhuis), "Putting Multimedia into Practice" (Mark Vegting), and "Adaptable Educational Computer Simulations" (Willem Jaap Zwart, Albert F. J. Rhemrev, and Andre M. Berloth); and (3) "Multi Media Technology" includes "A Look at Multimedia" (Jan Evers) and "QuickTime" (Jacob Sikken). Conclusions are drawn by Ivan Stanchev and Jan Schoenmaker. Most of the papers contain references. (TMK)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 367 305

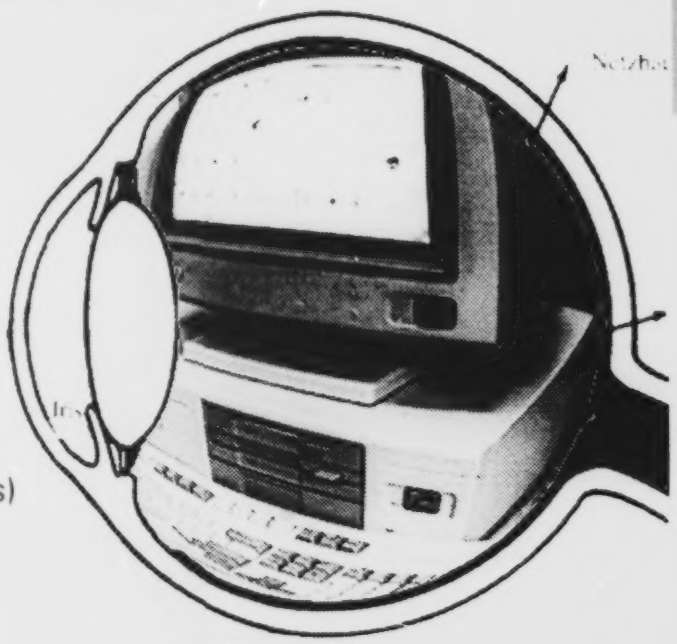
U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Principles and tools for instructional visualisation



Jan Schoenmaker
Ivan Stanchev (eds)

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

J. Nelissen

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

1120653 29

faculty of
EDUCATIONAL SCIENCE AND TECHNOLOGY
Andersen Consulting - ECC
The Netherlands

University of Twente
ANDERSEN CONSULTING
ARTHUR ANDERSEN & CO. SC

IR

Principles and tools for instructional visualisation

Colophon

Editors:	Jan Schoenmaker
	Ivan Stanchev
Design:	Hanna Snijder
Printing:	Reproduction department
	University of Twente

A publication by:
The Faculty of Educational Science and Technology
University of Twente
P.O Box 217
7500 AE Enschede
The Netherlands

© 1994 Faculty of Educational Science and Technology, Andersen Consulting - ECC

Content

Editorial 1

Concepts in instructional visualisation 3

Visualisation and effective instruction - Jef Moonen 5

Principles and R&D aspects in instructional visualisation - Ivan Stanchev 11

Human factors and multi media design - Lex Bergers 31

Conceptual metaphors for the visualisation in interactive learning - Piet Kommers 41

Functions and design of video components in multi-media applications: a review - Plon Verhagen 61

Design and development of multi media applications 89

Designing multimedia applications - Maud van den Meiracker 91

Multimedia development tools - Jan Schoenmaker, Erik Nienhuis 101

Putting multimedia into practica - Mark Vegting 113

Adaptable educational computer simulations - Willem Jaap Zwart, Albert Rhemrev, Andre Berloth 123

Multi media technology 135

A look at multimedia - Jan Evers 137

QuickTime - Jacob Sikken 143

Conclusions 151

Appendix - List of authors and addresses 155

Editorial

This report reflects research and development of the Department of Applied Education, Division of Instrumental Science and Technology of the University of Twente in the Netherlands and Andersen Consulting - ECC, also located at the campus of the University of Twente, and part of the world wide consultancy firm Andersen Consulting.
Both groups carry out work on instructional technology and are exploring concepts of visualisation and the use of multi media.
This report addresses three aspects of instructional visualisation:

- concepts in instructional visualisation
- design and development of multi media applications
- multi media technology

Ivan Stanchev, Associate Professor ,Faculty of Educational Science and Technology, University of Twente.
Jan Schoenmaker, Associate Partner, Andersen Consulting - ECC.

Enschede, January 1994

Concepts in instructional visualisation

Visualisation and Effective Instruction

Jef Moonen

Abstract

In this paper the potential relationship between visualisation and effective instruction is being reviewed. Reference is made to the AIME concept introduced by Salomon. It is concluded that research in this area should taken into account aspects of costs, cost-effectiveness and motivation of the learner.

Introduction

Improving the quality of learning and instruction is a continuing objective of education and training. 'Quality' however, can be described in many respects. One perspective is to focus on the effectiveness of the learning material to support the instruction.

As the traditional classroom and training situation is being expanded with technological features, such as video, computer and multimedia there is considerable interest nowadays relative to the possibilities of graphical user interfaces of electronic learning material in relation to visual communication. Presenting, transmitting and processing information in visual, non-textual form is what is meant when we speak of visual communication. Non-textual symbols, pictures, graphs, images and so on that convey information are called visuals.

The importance of visualisation in electronic learning material is reflected in many authoring systems as they offer more and more-varied possibilities to include visuals into the courseware they produce. However, it remains difficult to derive guidelines with respect to the integration of visual communication in courseware design. Improvement of courseware design methodology is therefore necessary; in particular, by investigating the relationships between type of courseware and the functions of visualisation.

In that context there is a need for further development of theoretical principles of the visual communication, especially with respect to the following questions:

- In what circumstances does the mind prefer the more complex, dynamic, lifelike image to the seemingly simpler verbal one?
- How do non-textual symbols, graphics, still pictures and moving pictures contribute to visual communication?
- If visual literacy is the ability to understand, think, and create non-verbally, how should visual literacy be learned and trained?
- In what way will visual learning be of value in determining the (cost)-effectiveness of the learning process?

A special aspect is the inclusion of visual techniques in tools to handle non-verbal communication, and in tools supporting the courseware design process. The latter is a logical consequence of what is going on in computer science itself, whereby two new styles of human-computer interaction have become popular: 'programming through visual environments in which graphical elements play prominent roles alongside text, and iconic environments, in which users interact with the machine primarily by defining, pointing at, juxtaposing, overlapping and otherwise manipulating postage-stamp size images commonly referred to as icons' (Glinert, 1990, p. 1).

Answers to the above about visual communication should help to better identify the advantages and disadvantages for visualisation of information in courseware and courseware design, leading to a new set of questions:

- What kind of tools improve the process of visual communication in teaching and training?
- What kind of tools improve the process of courseware design?
- What are the aspects and the factors that determine the break-even-point of using visualisation in terms of cost-effectiveness of courseware design, development and implementation?
- How does visualisation improve the cultural portability of electronic learning material?

In addition, the evolution of human-computer interface technology will significantly change in the next decade, given the growing international research interest in virtual reality (Earnshaw, Gigante, Jones, 1993; Kalawsky, 1993). As with any new technology, there are pedagogical questions to be addressed as methods of instruction are extended from being dominantly text-based to multi-sensory based. Additional questions such as the following are also important:

- How is learning in a "virtual reality" different from that of a traditional educational environment?
- How are learning styles enhanced or changed by virtual reality?
- What kinds of research will be needed to assist instructional designers in developing effective virtual-reality learning environments?

Results from Research

Because of the evolving technology, visual messages in different forms can now be much easier presented than in the past. However, there are no consistent research results to support the hypothesis that by using visuals the effectiveness of what is being delivered is increased.

Print material and visuals

In relation to print material Fleming and Levie (1993) indicate for instance that 'although the results of research on the effects of using graphics are neither consistent nor compelling, most authorities and professionals are convinced that in many circumstances graphics help readers (especially poor readers) to use and understand instructional text' (p. 41), and 'although research has failed to demonstrate conclusively that using pictures in courseware (in this context text-based material) is related to motivation, their instincts tell many designers that good pictures really do motivate learners' (p. 46). In the context of

message design variables and with respect to the perception of pictures, Fleming and Levie present eight design guidelines. Their first and main guideline is that 'pictures are usually more memorable than words, and are thus useful when information has to be remembered' (p. 86). However, their second guideline is that 'pictures play many roles in instruction. It is therefore necessary to know precisely what a picture's function is intended to be before it is designed' (p. 86).

Graphic design principels and interactive systems

In their discussion of the design of effective visual presentation Baecker and Buxton (1987) report that the application of graphic design principles to the medium of computer displays and interactive systems is not a trivial process. They suggest that 'given the difficulty of the problem, good progress will probably be achieved through the multi-disciplinary collaboration of the technologist "telling us what is possible", the psychologist "telling us what not to do", and the designer "suggesting what to do" (p. 300-301)'.

Cognitive psychology and user-interface design

Gardiner & Christie (1987) investigate relevant areas of cognitive psychology in relation to user-interface design, and summarize their findings in 162 design guidelines. They discuss the relationship of the use of visual material and its impact on memory and conclude, based upon the dual-coding theory of Paivio, that 'our ability to remember the appearance of novel, unorganized visual patterns over the short-term is extremely limited. On the other hand, our ability to remember the identity of a concrete item is better when it is presented as a picture than as a printed word' (p. 128). And they further conclude that 'ideally interfaces should be designed to be flexible enough to allow the user to vary the amount of information they have to deal with at any time, and, conversely, should not allow users to "get away" with inadequate amounts of processing where the consequences of poor recall will be dire' (p. 157). More generally Gardner and Christie summarize research findings into two principles:

> (a) 'The probability of recalling an item increases as a direct function of the depth of processing at which the item was encoded when punt into memory. Depth of processing increases with the requirement to consider the meaning of an item and its relation to other items';
>
> (b) 'The probability of recalling an item increases as a direct function of the elaborateness of processing associated with its encoding into memory. Elaborateness of processing increases with the richness of the context information present at the time of the storage' (p. 159).

These principles lead to the following design guideline: 'Items which must be recalled from memory some time after being removed from the screen should be surrounded with supporting information to which they are related, and should be immersed in a visually rich environment' (Design Guideline 125, p. 268).

Guidelines for the design of visuals for information

Petterson (1989) presents practical guidelines for the design of visuals for information. He stresses that image variables should be considered in relation to content, graphic execution, context and format. In the design and production of visuals for instruction, pictures must obviously contain the information they are intented to convey and must be relevant to the situation. However, Petterson reminds us of the fact that understanding a message in a visual are different in various cultures as well as in different socia-economic groups.

Lanzing (1993) has also done research into this area.

Relationship between verbal and visual messages
In addition, effective human-machine interaction requires an understanding of the relationships between verbal and visual messages, between characteristics of the learning material and the instructional process, the instructional approach and learning styles. Verleur (1993) presents an interesting summary of research results in this context. Generally speaking, research results indicate that when audio and visuals are presented simultaneously, the visually presented information will be dominant (Jaspers, 1991). Another conclusion is that presentations which are focussing on two senses or using two channels including an iconic presentation and a linguistic approach (text or audio) are superior to a presentation using only one channel. The most powerful result of using multi-channel presentation forms are their positive impact on the motivation of the learner.

Empirical research
Although many guidelines appear in the literature about how to incorporate visuals into learning materials, most of such guidelines are based upon theoretically driven research. Such research tends to seek out simple paradigms which appear to focus succesfully on a single psychological process. It should be underlined that empirical research is necessary, as factors such as individual skills and knowledge and the use of multi-sensory channels can make significant differences to performance and motivation. In other words, general conclusions about the impact of visualisation on the effectiveness of learning material remain to be supported.
In particular a main focus for research are the circumstances under which visualisation realises a positive contribution to the quality of the instruction/learning process.

AIME: The Amount of Invested Mental Effort

An interesting approach with respect to the impact of television on learning was developed by Salomon (1984).
When the structure of a communication is more or less congruent with one's past experience, that information is processed rather mindlessly. When on the contrary, nonautomatic and effortful mental elaborations are necessary to capture the information, these lead to both depth and mindfulness. A measure to capture such efforts is called by Salomon "the amount of invested mental effort" (AIME).

Two other concepts affect the AIME executed by a person. The first is the learners' perceived task characteristics (PDC) of the task. The more demanding a PDC is, the more AIME will be expended. The second is the learners' perceived self-efficacy (PSE). According to Salomon: 'The more efficacious learners perceived themselves to be, the more they are likely to invest sustained effort in a task and persist in doing so' (p. 649) . Assuming that thorough and mindful coverage of information are characteristics of better quality of the instruction/learning process, Salomon argues that such characteristics will be obtained when the instructional process stimulates an increase of AIME.

The main issue with respect to visualisation therefore is not to investigate technical possibilities of new media in order to 'maximise' the portion of visualisation within an

instructional program. The main issue is to match the visualisation possibilities of new media with the characteristics of the learners, in order to maximize their amount of invested mental effort.

Do Media Influence Learning?

As we talk about visualisation, it is not the medium but its presentation formats that are of importance.
In order to better distinguish different aspects of media, Kozma (1991) defines the media in terms of their technology, their symbol system, and their processing capabilities.
Most common is to talk about media in terms of their technology: the mechanical and electronic aspects that determine their functioning and physical features. There are TVs, VCRs, CD-ROM players, slide projectors, etc.
The most interesting features of a medium however are its possibilities to present a range of symbols (for instance text, audio, visual), and its processing capabilities (for instance interactivity, search capabilities).
Questioning if media through visualisation will contribute to maximizing AIME clearly relates to the range of symbol systems the medium can present, and to its processing capabilities.

In Paragraph 2 it was emphasided that empirical research should be done in order to determine in practice the impact of visualisation on the effectiveness of the teaching/learning process. Given the different characteristics of media, this emphasis should not concentrate on the technical possibilities of new and future media, or on the comparison of one technical facility versus another. On the contrary, research should be planned in relation to new symbol systems and/ or new processing capabilities represented in new and future media. Unless a new medium creates such a new symbol system or a new processing capability, a new medium has to be considered as belonging to a specific class of media capable of a certain kind of presentation and information transfer.

In that respect, for instance, a product presented through CD-I is not essentially different from a product presented through a combination of a computer program controlling a interactive videodisc. In terms of instructional effectiveness there seems to be no reason why there should be a difference between these two media. However, there could be a significant different in terms of their cost-effectiveness.

Costs, Cost-Effectiveness and Motivation

Different media are not alike in terms of costs involved: costs with respect to procurement, and costs with respect to the development of learning materials. Neither are they alike in terms of their potential to motivate the learner, or put it in a broader context, to stimulate the AIME of the learner.

When the expected instructional effect for two media are more or less comparable, then the cheapest medium is the most cost-effective.

Given the wealth of traditional and electronic media that are now available, and given the fact that many of these media have comparable features with respect to the symbol systems they can represent, and comparable power in terms of their processing capabilities, the question of the cost-effectiveness of a medium is becoming most relevant. Analysis of data in the context of cost-effectiveness very often leads to the understanding that potential effects such as the instructional impact of a raise in motivation or change in attitude of the learners are not (well) represented in the measurement of the performance, while enlarged motivation of the learners seems to be the most apparent effect.

Conclusion

Research with respect to visualisation and media should be concentrated on investigating relationships between symbol systems--in particular visualisation--and processing features, learners characteristics and learning styles. In addition researching the instructional value of visualisation, both aspects--cost-effectiveness and motivation--should be taken into account.

References

Baecker, R.M., & Buxton, W.A.S. (1987). Readings in human-computer interaction. San Mateo, CA: Morgan Kaufmann Publishers.

Earnshaw, R.A., Gigante, M.A., & Jones H. (1993). Virtual reality systems. London: Academic Press.

Fleming, M., & Levie, W.H. (1993). Instructional message design: Principles from the behavioral and cognitive sciences. Englewood Cliff, NJ: Educational Technology Publications.

Gardiner, M.M., & Christie, B. (1987). Applying cognitive psychology to user-interface design. Chichester: John Wiley * sons.

Glinert, E. (ed.) (1990). Visual programming environments: Applications and issues. Los Alamitos, CA: IEEE Computer Society Press.

Jaspers, F. (1991). The relationship sound-image. International Journal of Instructional Media, 18 (2), pp. 161-174.

Kalawsky, R.S. (1993). The science of virtual reality and virtual environments. Wokingham, England: Addison-Wesley.

Kozma, R.B. (1991). Learning with media. Review of Educational Research, 61 (2), 179-211.

Lanzing, J.W.A. (1993). Visual aspects of the cultural portability of educational software: a literature analysis. Unpublished report. Enschede, The Netherlands: University of Twente, Faculty of Educational Science and Technology.

Petterson, R. (1989). Visuals for information: Research and practice. Englewood Cliffs, NJ: Educational Technology Publications.

Salomon, G. (1984). Television is 'easy' and print is 'tough': the differential investment of mental effort in learning as a function of perceptions and attributions. Journal of Educational Psychology, 76 (4), 647-658.

Verleur, R. (1993). The application of audiovisual material as a complement to printed instruction. Unpublished report. Enschede: University of Twente, Faculty of Educational Science and Technology.

Principles and R&D Aspects in Instructional Visualisation

Ivan Stanchev

Communication - a model of the process

How can we be clear and comprehensive in summarising the communication process in a single model ? We can't. So many complexities apply to human communication that we must settle for something less than completeness and clarity. But we can summarise some of the most significant aspects of the process, and we can sharpen our awareness of what goes on when we attempt to send and receive messages.
Contemporary scholars have offered dozens of definitions of communication, and it would be arrogant and unprofessional to come up with "a definition to end all definitions"; however, we offer this working definition of effective communication:

Effective communication occurs when a sender transmits a message and a receiver responds to the message in a manner which satisfies the sender.

Note a few implication of this definition:
- It focuses on *applied* communication. This brief definition deals with getting results through communicating effectively in social organisations; it does not deal with theories, experiments or philosophies which go beyond that goal.
- It accepts the *satisfying* concept. In social organisations, as in almost all human situations, we often accept what is less than perfect. As long as a situation becomes productive or meets our basic goals, we usually settle for it. Teachers and instructors tend to settle for a productive understanding, rather than pressing for clarification of every historical, linguistic, philosophical, or technical aspect of a communication. The time and energy involved in reaching a "perfect" understanding (assuming for the moment that it is possible) would be too costly.
- It assumes a *feedback loop*. In order to realise satisfaction, parties must get some sort of confirming response. This can be verbal or non verbal, written or oral. It can occur through observation, evaluation systems, dialogue, and so on, but somehow the sender must experience verification of an adequate understanding of the intent of the message. Of course, in the process of giving feedback, the receiver becomes a sender and the original sender becomes a receiver. In addition, the original sender may modify a message in the light of feedback. But at each stage, our definition assumes sufficient response to confirm adequate understanding.

The key word in the definition is the term "message". A "message" is a pattern of signs (words and pictures) produced for the purpose of modifying the cognitive, affective, or psycho-motor behaviour of one or more persons. The term does not imply any particular medium or vehicle of communication.

When we pay attention to a stimulus, we tend to give it an interpretation, whether the stimulus is verbal or non verbal. We base our interpretation on such factors as our general backgrounds, our loyalties, our vocabularies, our education, our expectations, our personal interests, our values and our prejudices. Because of such factors, distortions often occur as messages filter through channels. But by being aware of such factors, we can work toward encoding and decoding more effectively, and toward reducing "noise" in the communication process.

Visualisation and perception

In a letter to Jacques Hadamard, a friend of him, Albert Einstein speaking about himself wrote that words in their written or oral form did not play a significant role in his way of thinking and that to him the basic elements of thought were definite signs and symbols(Einstein, 1953).

Mastering of techniques for information visualisation and the ability to present this information as an explicit and simple drawing have great importance in many spheres of human activity - research, design and construction activities, books and printed matter layout, etc. Visualisation of information takes a particularly important place in educational systems since psychologists have proved that visual perceptions play a most prominent part in information memorising and reproduction and that memory is the result of the received perceptions which according to some theorists can be apportioned in the following way:

- 75 % visual perceptions;
- 15 % aural impressions;
- 6 % tactile perceptions;
- 3 % sense of smell, and
- 3 % taste.

All that is of great importance when interactive courseware is being thought out and designed since the computer screen is the main source of information in the user's communication with a program. If the program's creators have not made it visual enough it could be difficult for the trainee to interact with it without using additional information from other sources (for example, from the teacher or a guide for work with the program). In contrast, the design of visual objects demonstrating the program's potential and content can improve the ease of comprehension and sound memorisation of the information contained in the program.

The process of artistic designing (visual design) is very close to the theory and practice of fine arts - it is subjected to the same principles with regard to the means of the composition (symmetry and asymmetry, metrics and rhythm, contrast and nuances, proportions, scale, colour, texture, etc.). The observation of these principles increases the strength of the impact of the information apprehended - a fact well known and used in the fields of ergonomy, aesthetics and design. On the basis of these principles a number of important and fundamental principles in the visualisation of information can be formulated:

The principle of conciseness. The graphic means for information presentation should contain only such elements which are indispensable for conveying essential information to the viewer and this information *must* be *comprehensible for it* represents the visual accent of the basic composition elements. It is useless to try to draw attention to the most important characteristic features of a situation if they are surrounded by superfluous visual distracters having no bearing to them and hindering the apprehension of the essential (see Fig. 1).

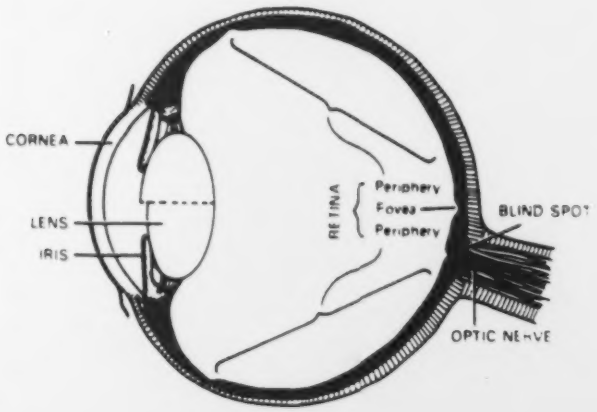


Figure 1

The principle of generalisation and unification. The basic forms for graphic presentation of information must not be needlessly broken to pieces or include elements designating superfluous details from the standpoint of the presented information. This form must be rationally generalised and the symbols denoting the same objects and phenomena must be unified, i.e., they must have a unified graphic solution (see Fig. 2).

Figure 2

The principle of accent on basic notional elements. In visualising information the elements most essential for information comprehension by the viewer should be set apart in size, form and colour. In some cases it is even possible to allow a conscious breaking-down of the proportions of symbols' sizes with respect to the real objects depicted by them (see Fig. 3).

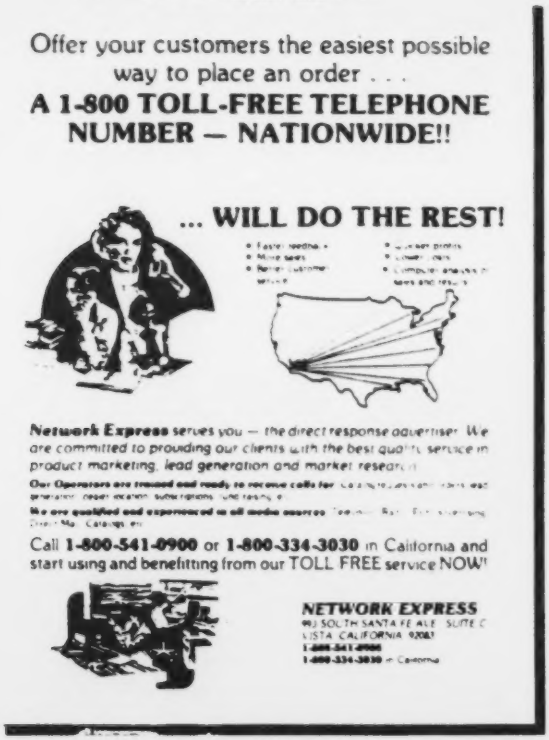

Offer your customers the easiest possible way to place an order . . .
A 1-800 TOLL-FREE TELEPHONE NUMBER — NATIONWIDE!!
... WILL DO THE REST!
Network Express serves you — the direct response advertiser. We are committed to providing our clients with the best quality service in product marketing, lead generation and market research.
Call 1-800-541-0900 or 1-800-334-3030 in California and start using and benefitting from our TOLL FREE service NOW!
NETWORK EXPRESS

Figure 3

The principle of autonomy. The graphic presentation of information concerning autonomous, independent objects or phenomena should be set apart and clearly differentiated from the remaining components of the image. In practice it means that the decomposition of the complex graphic information into separate simple images facilitates considerably its perception and comprehension (see Fig. 4).

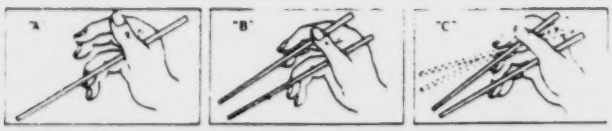


Figure 4

The structural principle. Every autonomous component taking some central, crucial position in the graphic expression must have an exact and easily remembered structure differentiated from the other components. This structure, as well as the structure of the whole graphic image must conform to the logic structure of the real object or phenomenon's decomposition (see Fig. 5).

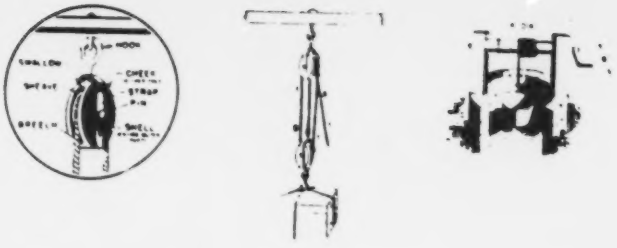


Figure 5

The phasic nature principle. The behaviour of dynamic objects and phenomena presented through the means of information visualisation should be decomposed with respect to time and space. It helps not only to understand and acquire the mechanism of this behaviour but provides a procedural logic which should be presented with the assistance of various graphic means (see Fig. 6).

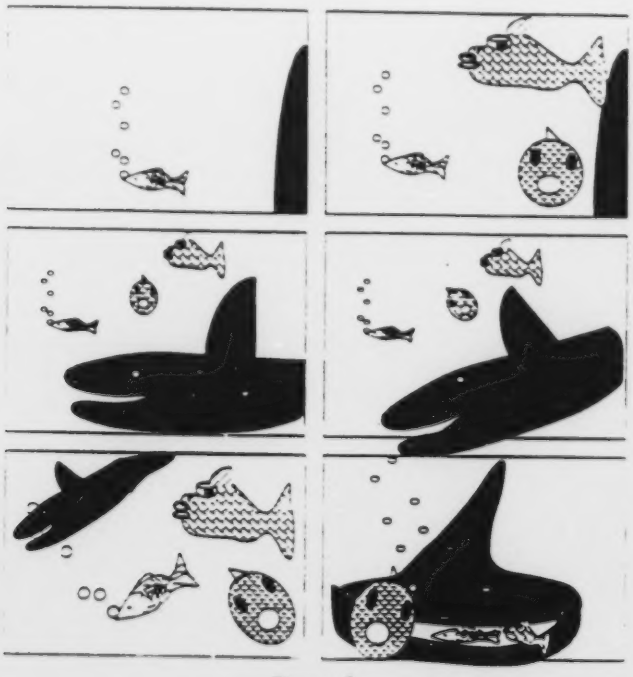


Figure 6

The principle of use of fixed associations and stereotypes. In creating graphic forms for information presentation the stable, habitual associations between the symbols and the objects and phenomena designated with them must be recognised as well as the stereotypical reactions of the viewer to definite symbols and signals. It means that where it is possible one must not use abstract, conditional signs but symbols which lead through association to the respective objects and phenomena. On the other hand, however, one must bear in mind that the naturalist, detailed presentation of the outer appearance of the objects keeps the viewer's thought on the outer similarity with the object and impedes the realisation of the more essential, from the point of view of the presented information, characteristics and regularities (see Fig. 7).

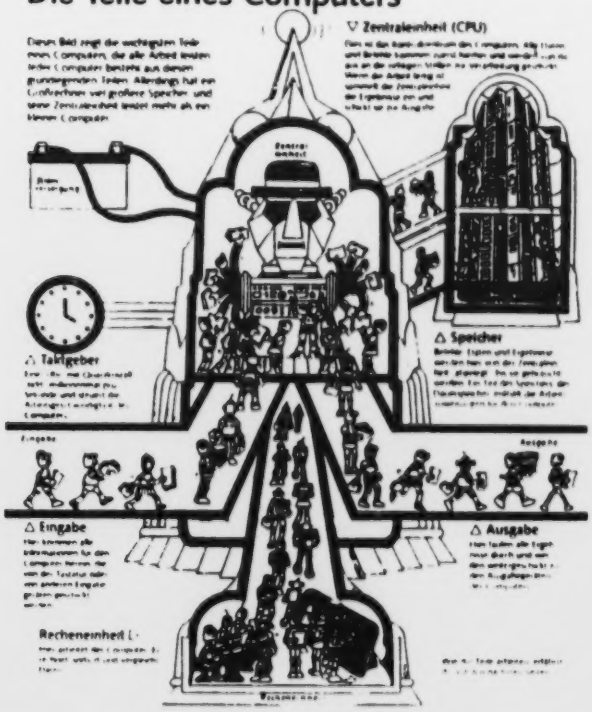


Figure 7

How can abstract principles be applied to concrete instructional problems? One means of facilitating this transfer is to state both propositions (both the principle and the problem) in parallel forms. This form can be generalised as: "What conditions lead to what results?". In (Fleming and Levie, 1978, pp.15-18) is given a excellent example for applying this approach using the basic principles of perception for some general guidelines for the instructional designer.

Basics of visual communication

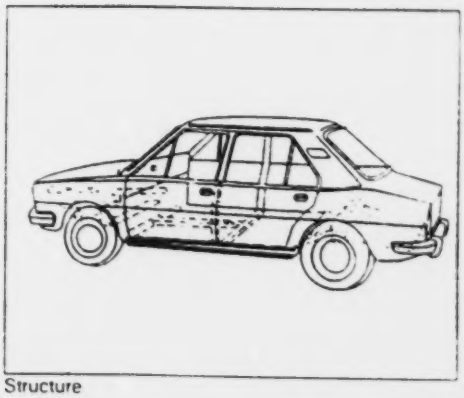
Specialists in the field of visual communication maintain that a drawing is worth thousands of words and this is really so provided the drawing is good. The difference between words and a drawing is that with the assistance of words we narrate while a drawing shows. However, in order to achieve the desired result the possibilities of the graphic language must be mastered. If the meaning of a text is revealed through words, the illustration "speaks" in the language of forms. The communicative possibilities of the graphic language can be understood if we analyse the goals of visual communication, i.e., if we try to answer the questions What? How? How much? and Where? with the help of graphic expression (Fig. 8):

- **What** does the object represent? What is it? - it is a question which refers above all to the *outer appearance* of the object, its physical *structure* or the logical relation of its parts to the whole. Most often questions refer to the visual perception of the object's properties, but they can also refer to such properties which are invisible under ordinary circumstances and also to definite abstract notions connected with the *organisation* of the object itself.

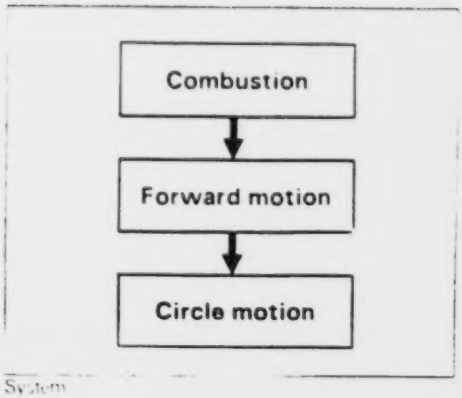
- **How** does one or another object operate? This is a question which concerns its *physical movement*, the *logic's of functioning* of its separate parts within the frames of the whole as well as the *process of functioning* of the whole object as a sequence of interrelated conditions. In these cases the demonstration of actions in static images requires the use of symbolic forms displaying movement. It applies with equal force both to real physical objects and phenomena and to ideal models presenting an abstraction of reality.

- **How much** refers to the quantitative characteristics of the object, i.e. to the physical *dimensions* of the object, the *quantitative relationships* between its components and elements as well as to their *correlation to the whole*, the tendency of alteration of the physical characteristics, etc. The quantitative analysis of the object and its image involve compulsory a process of abstraction.

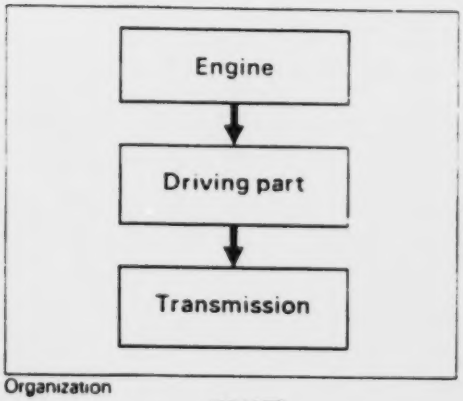
- **Where** is a given object located or a given phenomenon take place? This is a question which refers to the *place* of the object, its *location* in space, its *position* with respect to other objects. Very often the differences between these three characteristics are difficult to detect but the basic questions relevant to them can be differentiated according to their functional meaning.



Structure

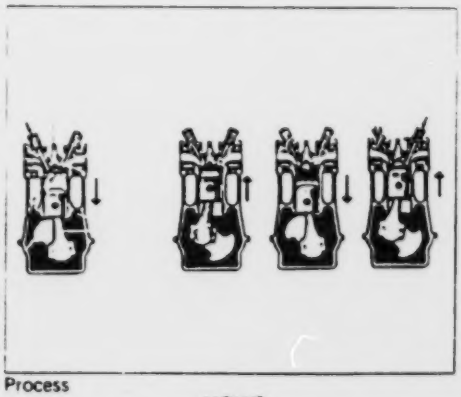


System



Organization

WHAT?



Process

HOW?

Figure 8

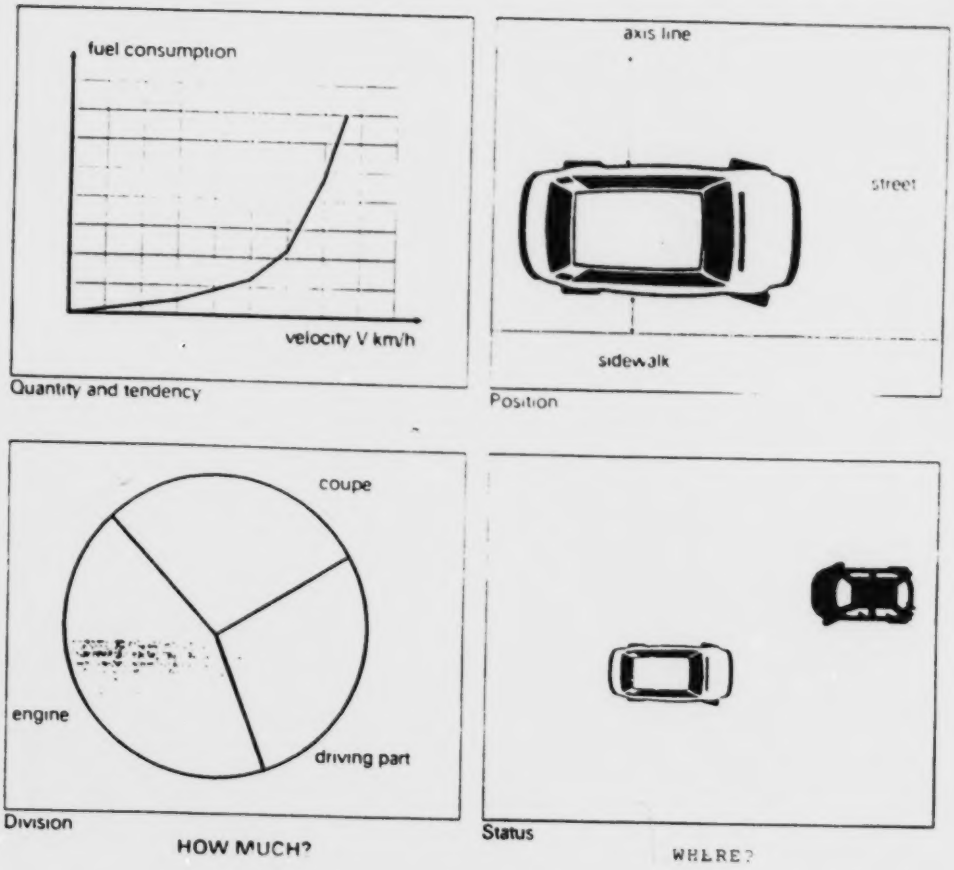
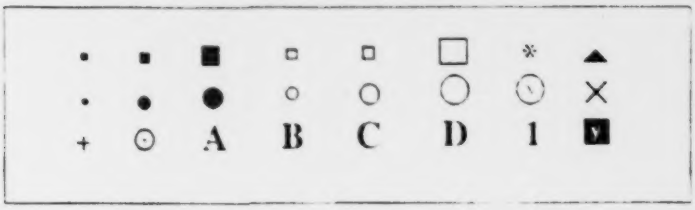
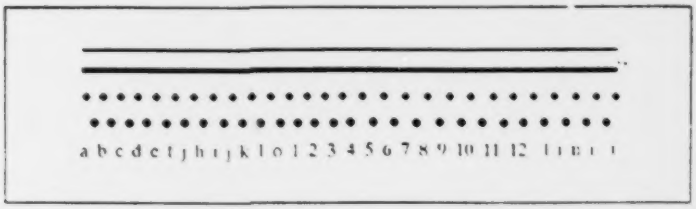


Figure 8[b]

Visual language has like any other language a syntax's, semantics and pragmatics. The lowest level elements of forms, comparable to the characters of verbal language, are well known from geometry - **point** which has no dimensions of its own but shows a place, location and position, then **line** as a one-dimensional image. On the intermediate level, comparable to words, configurations of the lower level element get a basic meaning.

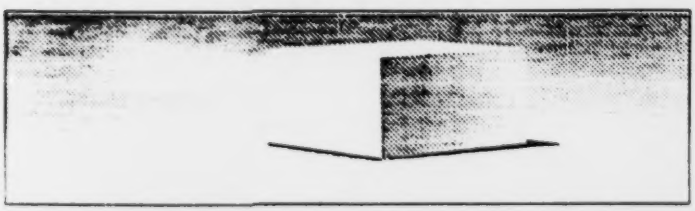


Point

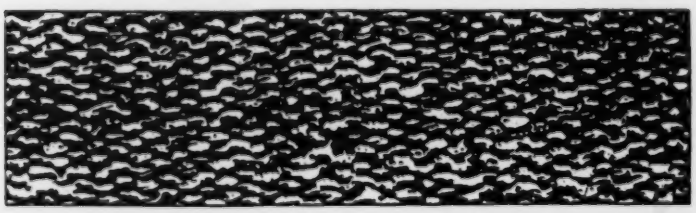


Line

Flat shape (spot)



Tone, tonality



Texture

Figure 9

On the high level the "words" of visual language combine to form expressions. Through line we most often show direction, stretch or movement. As an element of the word stock line can be used also to depict trajectories and routes, to designate boundaries and divisions. The regular and irregular geometric figures as well as the plane forms are a two-dimensional image of some type. Space occupied by them coincides with a definite area of the drawing. In this sense the figure as an element from the dictionary of the graphic language is used to designate contours, area, outline, frame, etc.(see Fig. 9).

The definite hue, i.e. a relationship between the degrees of black and white as well as the colours, affords us a possibility to distinguish between separate elements of the object or to accentuate on the basis of contrast. Smooth transition and use of light shades allow us to describe volumetric forms and perspective changes (see Fig.10).

The texture of the graphic image is in fact the surface structure of the drawing and here we can use both abstract and symbolic and descriptive textures. In practice, they denote properties of the physical surfaces of the object and are usually used with other elements of the form - most often they are combined with colours.

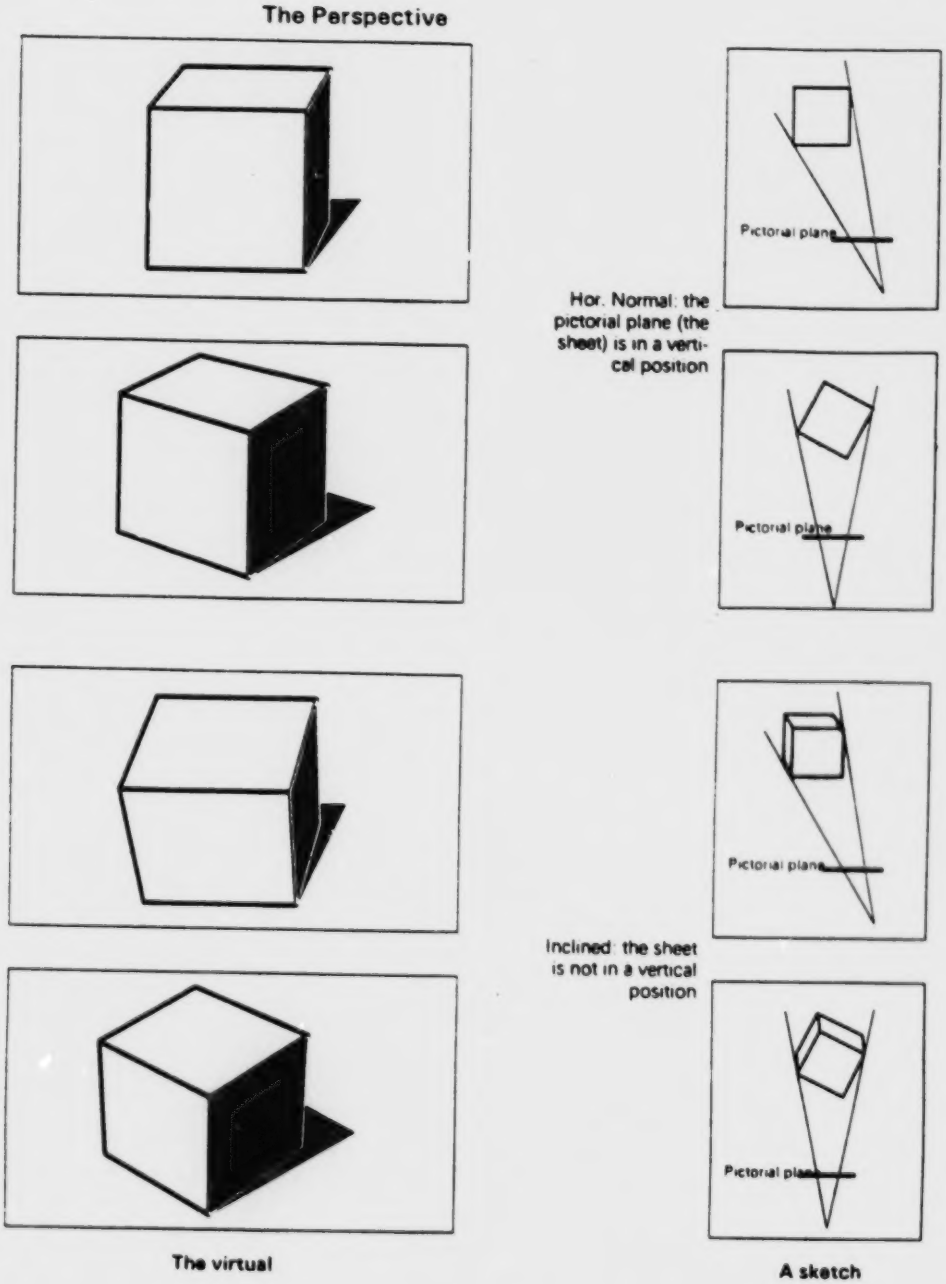

The Perspective
Pictorial plane
Hor. Normal: the pictorial plane (the sheet) is in a vertical position
Pictorial plane
Pictorial plane
Inclined: the sheet is not in a vertical position
Pictorial plane
The virtual
A sketch

Figure 10

Graphic language together with its elements is not created for its own sake - the form, the space and the visual interaction are means for presentation of definite ideas, objects and phenomena. That is why visualisation always begins by setting some definite goal and then a content corresponding to the goal is chosen which is translated into the language of visual forms. It is afterwards that the drawing is constructed and in it the visual language is wholly used to develop and specify the visual image and its transformation into a visual model. That means that the **conception** or the visual idea, the **artistic design** and the **graphic execution** are the three main stages in the process of information visualisation.

What are the practical conclusions that we should drawn when visualising the information in interactive programs? Above all the conclusions are relevant to the graphic design of the separate "screens" presenting a basic element in the process of human-computer interactive interaction. The development of computers, and personal computers in particular, the extension of their possibilities to work in the graphic mode, eliminates the difference between artistic design by means of paper, pencil and coloured pencils and design with the assistance of specialised computer packages of applied programs for information visualisation.
The computer offers something more - while in the classic visualisation of information it is impossible to apply the animation approach with computers as a result of their quick operation and the consecutive deposit of images perceived by the human eye as a continuos alteration of the image we gain a number of additional possibilities for visual impact.

Advantages and disadvantages of visualisation in education and training

To be able to use visualisation to its maximum potential we need to understand what characteristics of visualisation cause it to be advantageous. In this way we can better estimate when visualisation will be the most beneficial.

Psychological and instructional aspects
The acceptance of individual differences leads to three possible approaches. The first approach is to make understanding as easy as possible for each individual by supporting both text and visual modes of presentation. The second approach is to present only the mode that best fits the individual student. Thirdly one can argue that everyone should be proficient in reading both text and visuals, so making it too simple would not stimulate the reader/viewer to train his abilities. We guess the solution to this dilemma lies in the nature of the instruction. The question whether or not to teach visual literacy is strongly related to questions of teaching common knowledge, it does not explicitly belong in the school curriculum but it is expected from good general education. Training and reschooling of adults has less general and more specific goals and the designer of learning materials in this area may therefore try to optimise learning outcome by neglecting such goals as visual literacy and optimise the learning by teaching in the mode most suited for the individual learner.
A disadvantage of visualisation of the learning content is that many times the link between the symbol and its meaning are more or less arbitrary, based on associations of the mind.

Because of individual differences one can never be certain someone else will have the same associative link and will therefore be able to correctly interpret the symbols used. On the other hand comprehension can be facilitated by adding context to the symbols. A lonely "trash can" icon on a computer screen could mean many things (time to put your garbage can on the sidewalk, what you have just typed is trash, etc.), adding it to the rest of the desktop concept (icons for disks and files, the windows and menus) could easily lead to the conclusion that the trash can can be used to throw away files and discs.

Several instructional theories focus on the dilemma of either working from abstract to concrete or the opposite. Romiszowski (1981) describes for instance Bruner's classification of three levels of representation; -- inactive, iconic and symbolic, advancing from concrete to abstract (p. 173) -- and Landa's concern about the rule/example sequence (RUL-EG vs. EG-RUL) (p. 179). Examples are usually used to present information realistically, but text is an abstraction itself. To make the best use of examples they should be as realistic as possible. An obvious way to do this is to make use of visualisation. Metaphors are used when a topic has no intrinsic realism. To make the topic more accessible an analogy is found between the topic and a less abstract phenomenon. The metaphor may be visualised and therefore given more realism. In terms of Bruner this will enable students to gain iconic experience with symbolic topics. Direct manipulation (Shneiderman, 1990) of abstract information is possible by visualisation of the metaphor. A major difference between text and visuals from a psychological point of view is the difference between the sequential nature of text and the parallel nature of visuals. For text a predefined direction of processing the chain of characters and words makes it a sequential mode of presentation. For visuals there is no predefined direction of reading, therefore it is possible to display simple items in such a way that it is easy to view the items 'at the same time'.
The motivational aspect of visualisation is clear (Keller, 1983). Programs that look nice are fun to work with. Of course one runs the risk of distracting and therefore decreasing the learning effects, but in general the more motivated the learner is the better he learns. Although motivation from the niceness of visuals is extrinsic, and less beneficial than intrinsic motivation, the general attitudes towards the learning task, towards the program and towards computers are positively influenced by such feelings as the comfort of working with the program and the perceived locus of control (Hartley & Lovell, 1984).

Cross-cultural aspects
Since the beginning of written language people have realised that communication using the arbitrary rules of language is not equally understandable for all. The chance of not understanding the associative relations between symbol and meaning increases when cultural differences between sender and receiver become larger. In general one can say that the less assumptions are made about the rules of communication, the greater the probability of understanding. Communication by text requires language, and language is from this point of view nothing less than an enormous amount of communication rules. By using text the sender assumes the receiver will be aware of these rules and will know how to apply them (quickly enough) to process the message. Language is part of culture; therefore often cross-language will also mean cross-cultural. Cross-cultural communication by text is therefore a problem unless sender and receiver can agree to use one set of rules (one language), provided they possess knowledge of a common set of rules (speak a common language).

Pictograms are iconic symbols. Using graphical representations one can create an icon language, which is again a set of rules, but the associative link between symbol and meaning should make the icon language more culturally independent than text. Examples are the pictographic language for traffic regulations or the icon language for organisational and functional focusing of areas and facilities in communication and meeting environments (airports, railway stations, conference centres, etc.). The discussion by Ossner (1988, pp. 8-11) follows the same lines of reasoning and reaches the same conclusions.
To increase the portability and effectiveness of educational software we have to investigate and to apply the full range of cross-cultural advantages of using visualisation (Lanzing, 1991). All these advantages have to be transformed into practical principles and guidelines for software engineers and instructional designers involved in the development and implementation of educational software.
There is however one less positive remark about the advantages of visualisation. The possibilities of visuals to express verbal information detailed enough to communicate whatever you would want to communicate are limited.
What we have been trying to communicate using pictograms has so far been relatively easy to say; "go there", "exit over here", "no smoking allowed", etc. To express more complicated things using graphical communication might not make understanding easier, but at least everybody is equally unfamiliar with the symbols used, which could by itself increase mutual understanding.

Technical aspects
Every computer is well equipped to display characters, but only a few of them offer enough built-in aids to make the programming of an interactive system on a graphical screen easy. Also the absence of one standard graphics adapter requires the programmer of graphical software to invest great efforts to make the courseware run on most computers. To overcome this problem one needs to use either an authoring system which supports graphical interaction or a library with adequate graphical functions or objects.
Without the right tools the development of a program that uses visualisation will take considerably more time and effort and therefore more financial means. Depending on the goals, the available tools and experience using them, the difference between the production of courseware in text and in graphical mode will decrease. In the end it might even become cheaper to produce graphical courseware due to improved authoring tools.
The most important limitation of the design of graphical software is the skill needed to produce acceptable graphics. To guarantee an acceptable standard of graphical design one really needs a professional graphical designer to make it look professional. No student can be fooled to work with courseware that looks amateuristic; however good the concept, the instructional design and programming may be, users look at the screen and if they see amateur graphics they will not be confident about the quality of the rest of the program. Of course this will significantly increase the costs of courseware production.
Several techniques for visualisation in courseware engineering are at our disposal. Multimedia techniques combine the advantages of normal video (quality moving images, good production methods) with the interactivity of computers. But the application of these methods still require special devices, installed both with the designer and the user of the courseware. This causes investments which are presently too high for most educational institutions.
Commercial organisations are more and more using such multimedia techniques for company training, where the costs of such techniques are low compared to personnel

costs. This increased usage will probably cause the prices of technical support for visualisation to decrease a little, but we are still not very optimistic of the chances of the technology for handling these techniques being afforded in schools in the near future.

Graphical techniques use the computer to display either prepared images stored on a computer-readable external medium or images instantly generated by the computer. Because it requires no extra equipment, these digital approaches are usually the cheaper techniques. Therefore these techniques will be used more often. But apart from these economical aspects, digital graphical methods for visualisation are also superior in versatility. Since the image is fully digital the computer can do all sorts of things with it, ranging from adding arrows and marks to image processing.
For a long time the quality of computer graphics has been rather poor and with a low degree of realism, due to both display technology and to the difficulty and labour intensiveness of entering pictures into the computer. The use of scanning techniques has increased the quality of the visuals. The only remaining limitations are the amount of memory necessary for the storage of the images and the speed with which the huge amounts of image data can be processed to produce realistic moving images.
Digitalisation of video, compression techniques and increased graphical resolution and colour will make the gap between the appearance and presumably the effect of both methods smaller. It now seems obvious that the trend towards digitisation of all kinds of information will also progress towards the digitisation of video. Several attempts in this direction, such as DVI and Apple's QuickTime, have been undertaken and may prove to be practical enough to become popular.

Economical aspects
Visualisation always increases the costs for the courseware development. A reasonable problem, not solved until now, is to find the cost-effectiveness point of satisfaction taking the important advantages and disadvantages, described above, into consideration. The solution of this problem is difficult not only because, one cannot estimate exactly the direct and the indirect costs of courseware visualisation at the beginning of the development process, but mainly because till now there is no reliable model to convert the qualitative measured effect from interactive visual-supported courseware into quantitative (and special monetary) figures, for comparison with the rough estimated costs.
The economic aspect is connected with the aspects mentioned above, especially with the cross-cultural one through the portability problem which influences implementation. From the other side, the technical aspects are connected with the costs of software development and therefore indirectly with the level of visualisation.
All the aspects therefore are related and so to study the main research problems a systems approach should be used.

Application of visualisation in courseware engineering

Two directions of visualisation in courseware engineering can be distinguished. The first and most obvious is the visualisation in courseware itself, to improve the learning process. The second is the usage of graphical representation, for instance in authoring tools, to improve the courseware engineering process.

Visualisation for learning

The advantages mentioned before indicate the value of visualisation for learning. Many visualisation techniques are useful, both from the domain of multimedia and graphical methods of visualisation. The effort required to implement visualisation in courseware will depend largely on the development system used, but also on the availability of scanning hardware and on the capabilities of the development team in producing quality visuals or on the availability of legally usable visual materials.

Depending on the learning content of the courseware, the visualisation can serve several functions. Molitor, Ballstaedt and Mandl (1989) offer a useful classification of these functions:

- *Representation*. The representational function serves to transmit information, usually redundant with text. The use of the representational function of visuals depends largely on the instructional content because it has to be concrete, visible. While a verbal description of the face of a persons may be detailed enough to serve the educational purposes, it cannot be denied that a picture of a face is much easier to interpret and remember.
- *Organisation*. The organisational function provides an overview or macro structure of the text content. This way the visualisation will probably have the advantages of the advance organiser, but with the extra advantage that it can easily be referenced. Knowledge navigation is one of the major problems in the educational use of large databases such as hyper documents used in discovery-type learning packages. The provided overview of the macro structure may also serve as a kind of navigation tool.
- *Interpretation*. The interpretation function helps the reader to understand parts of the text, for instance by visual analogies and metaphors. An example of an interpretational use of visuals is the depiction of sets using Venn-diagrams or the use of histograms to show the development of the value of a variable over time.
- *Transformation*. The transformation function enhances memorisation by providing the learner with extra associative links. The keyword technique (Pressley, Levin, & Delaney, 1982) makes use of this function of visualisation.
- *Decoration*. The last function, decoration, is used to beautify the text.

The decorative function is not much appreciated by Molitor, Ballstaedt and Mandl (1989), because it can produce negative effects. We think the decoration function itself increases motivation and will therefore produce a positive effect, if not overdone. But we agree that an illustration serving only a decorative function will probably distract because the student will start to wonder about the educational value of the illustration and will spend his time trying to find out the deeper meaning. This categorisation of visualisation functions should not be confused with a categorisation of visuals, in which case one could talk about a decorative picture.

Visual aids for courseware engineering

Advocates of authoring and visual programming systems often claim that "non-programmers" should be able to develop their own software. However we do not consider programming by teachers who are not proficient in programming a good approach. The effort required to make good educational software is much too large to fit within the frame of lesson preparation. We do recognise the desire of teachers to influence the instruction delivered by courseware products. Adaptability of courseware will become more and more important over time when teachers start to integrate courseware in their normal curriculum. As with ordinary school-books, teachers will want to make additions after some years of usage.

Visualisation techniques may help to build systems, that enable teachers to make minor changes to existing courseware, such as removing a paragraph or adding one, replacing a picture, etc.

Other types of courseware, like simulation, modelling and gaming require different characteristics from the authoring system. Modelling systems for instance are programs that allow the user to enter, change and calculate mathematical models. Such programs usually use some kind of visual representation to indicate the transfer of data from one function or block to the next, such as an electrical circuit where the electrical current passes through different components which transform the signal.

Rapid prototyping tools have become increasingly popular in recent years. Rapid prototyping tools are systems that allow experienced programmers to make a mock-up version of software to be developed to discuss about and test the program before it's actually being programmed, usually in some higher programming language. The role of visualisation for rapid prototyping tools is obvious, because the major function of such tools is to produce programs that look like how the final version of the courseware under development should look like. It should give all the people involved in the courseware development process an idea of the functioning of the graphical user interface and the educational interaction.

References

Alesandrini, K.L. (1987). Computer graphics in learning and instruction. In H.A. Houghton & D.M. Willows (EDs.) The Psychology of Illustration, 2 (Instructional Issues), pp. 159-188. New York: Springer

Cole, M. & Scribner, S. (1974). Culture and thought: a psychological introduction. New York: Wiley.

Dwyer, F.M. (1971). A study of the relative effectiveness of varied visual illustrations. Educational Technology Publications.

Einstein, Albert.(1952) "Letter to Jacques Hadamard." In "The creative Process. New York, New American Library, pp. 43-44.

Fleming, Malcolm and Levie, Howard.(1978) Instructional message design. Educational Technology Publications, Inc., Englewood Cliffs, New Jersey.

Hartley, J.R., & Lovell, K. (1984). The psychological principles underlying the design of computer-based instructional systems. In D.F. Walker & R.D. Hess (Eds.), Instructional Software: Principles and perspectives for design and use (pp. 38-56). Belmont, CA: Wadsworth.

Keller, J.M., Development and use of the ARCS model of motivational design 49832. University of Twente, Enschede.

Koenig, J., Bryant, R., e.a. (1991). HyperCASE: The visual application development system [computer program manual]. Toronto: Interactive Image Technologies.

Lanzing, J.W.A. (1991). Visual aspects of the cultural portability of educational software (unpublished doctoral literature survey). Enschede: University of Twente.

Molitor, S., Ballstaedt, S.P., & Mandl, H. (1989). Problems in knowledge acquisition from text and pictures. In H. Mandl & J.R. Levin (Eds.), Advances in psychology: Vol. 58. Knowledge acquisition from text and pictures (pp. 3-36). Amsterdam: North-Holland.

Ossner, J. (1988). Transnational symbols: The role of pictograms and models in the learning process. Pre-DELTA Project TF III task e (paper 5).

Pressley, M., Levin, J.R., & Delaney, H.D. (1982). The mnemonic keyword method. Review of Educational Research, 52(1), 61-91.

Romiszowski, A.J. (1981). Designing instructional systems: Decision making in course planning and curriculum design. New York: Kogan Page.

Rivlin, Ch., Lewis, R. & Cooper, R.D. (Eds.) (1990). Guidelines for screen design. Blackwell Scientific Publications. Cambridge: The University Press.

Shu, N.C. (1988). Visual programming. New York: Van Nostrand Reinhold.

Simonson, M.R. & Hargrave, C. (Eds.) (1991). Proceedings of the 13 annual AECT conference. (IA): Iowa State University.

Stanchev, I. (1990). Software engineering for portability. Journal of Research on Computing in Education, 23(2), pp. 204-224.

Stanchev, I. (1991). Visual presentation of information and design of interactive screens, proceedings of the IV East-West seminar on education technology, Prague, 1991.

Stillings, N.A., Feinstein, M.H., Garfield, L.J., Rissland, E.L., Rosenbaum, D.A., Weisler, S.A. & Baker-Ward, L. (1987). Cognitive science: an introduction. Cambridge (MA): MIT.

Tyre, T. (October, 1989). Authoring packages continue to mature. Technological Horizons in Education Journal, 17(3), 10-18.

Human Factors and multi media design

Lex Bergers

Abstract

Some human factors in relation to multimedia design will be discussed in this article. In the first part theory and design guidelines about human communication is applied to 'man-machine' communication. In the second part of the article some cognitive processes -perception and storage and retrieval of information- that affect multimedia design are described.

Introduction

Multimedia is all about communication. So, let' s spend a minute on a simple definition of *human* communication: sending and receiving messages between two or more people. Someone is sending the message and another person is receiving it. The sender can then become the receiver and vice versa.
This communication process comprises different subprocesses e.g. motivational and cognitive processes.
The communication between a human being and a (multimedia) system basically follows the same process. There is a sender (the system), there are messages (the content), there are receivers (the users of the system) and there is feedback (the system reacts at the input of the system user).
The major difference between 'man-machine' communication and communication between people is the lack of flexibility in the communication process. There are no side paths possible, there is always a kind of (more or less) rigid communication. It is impossible for a system to act or react as a human being, to understand what troubles the user has or why the user is not able to proceed.

However, designers of multimedia systems can take into account 'human factors' as much as possible to let the communication process be as optimal as possible. By 'human factors' I mean the psychological attributes that are involved in communication processes, including motivational processes and cognitive processes like perception, attention, memory, learning and thinking.
In this article I will concentrate on some important notions about communication and on two cognitive attributes: perception and memorisation (storage and retrieval of information).

Although psychology is a very young science, designers of multimedia systems can benefit from it. To become a good designer, especially a user interface designer, it is most needed to have at least some knowledge about human factors.
So, the discussion is about what human factors can bring in order to develop guidelines for multi media design.

Sending messages in communication

You probably know what coins are used in the United States of America. So you should be able to solve the next problem. 'I have two coins that total 30 cents. One of them is not a five-cent piece. What are these coins?
Do not read further now. Think first about this problem before you read the solution.
Of course, there is a trick. The solution is a five-cent piece and a quarter. Why? One of the two coins (*the quarter!*) is not a five-cent piece!
Most people cannot easily solve this problem, because they trust communication conventions too much, like the one that people trust that when there is some special condition, it will be described. If special conditions are not mentioned, then the 'receiver' can assume there are none.
In designing multimedia systems this means that the system has to always inform the users about special features that are not visible at first glance. The user interface must reveal the special features. The user should be able to perceive the message in its context. If the context is absent or unclear then understanding becomes more difficult.

Another communication convention is that people normally do not mention obvious, unimportant, or unlikely things. When people do mention them, it conveys a special signal about their importance.
Here is a danger, because the sender (the designer) determines what will be obvious to the user and what will not. The only way to avoid problems is to do several user tests and find out if it really is obvious to the users.
Communication is not always very effective because of inconsistencies and ambiguities in the process. This does not mean it is not possible to have effective communication. What is the best way to send messages to a computer user with whom you are trying to clarify your intentions? There are some rules to be aware of:

Consider the knowledge of the user
Always consider the knowledge and understanding of the system users. The users often do not have the same background you as a designer have, they may have an entirely different concept of what you are speaking about. Do not use terms the system users do not understand. Try to avoid difficult and ambiguous terms, if this is not possible define them. As much as possible, let the system speak the language of the users.
Of course users differ in capability and experience, try to design with these differences in mind.

Present complete messages
Ensure that the messages in the system are as complete as possible. Give explanations where needed.

Do not use negatives
Negatives in a sentence will be read slower and less accurately than comparable sentences phrased in affirmative terms.

Provide messages and orientation possibilities
Provide messages informing users which part of the system they are in. In large systems users may forget which facility they are using, beacuse they have navigated through many functions. A support function showing them where they came form and where one can go to, might be very helpful.

Save user's effort
Try to save user's effort when operating the interface. This can be realised by using the minimal number of dialogue steps necessary. For example, do not use two question and answer steps where one will be sufficient.

Reduce the amount of typing
Reduce the amount of typing and the use of abbreviations and codes. Long winded dialogues may be supportive at first but users quickly learn dialogue steps. Slow and multi-step dialogues soon become frustrating.

Use defaults.
Set default replies where there is a predictable answer; this saves the user work.

Help
Provide on-line help whenever possible. Help has two functions, first as a learning aid for users who are reluctant to read manuals, second, as a memory support for experienced users who need confirmation of some detailed aspect of an operation.

Undo
Mistakes will be made and users will want to backtrack in a dialogue the sequence they have gone through and start again. The interface should provide the ability to go back (or go 'up' in a hierarchical system) and recover a previous state.

Consistency
The format and the execution of commands should be consistent throughout the interface. Consistency reduces the amount users have to learn about an interface.

Presenting feedback in communication

In multimedia systems, feedback is the user's *key source* of how to complete a task. Feedback takes away the fear from the user, it helps the user to feel at ease because it confirms that the system did understand him (and visa versa). Feedback makes it possible for the user to correct words or actions and it gives the user new incentives.
If feedback messages are not well expressed, it will disturb the communication process. If you give feedback that is not useful at that moment or if the feedback does not tell what to do instead, it does not help at all. For example:
If one receives the feedback message "You have to select another function," you do not know what to do, or which function you should select. Feedback has to be constructive, it must help the user to proceed. A good example is: "You have to select the delete function."

If a user receives negative feedback, he will not feel at ease and this can be demotivating. It will be more motivating for the user to receive positive, constructive feedback. For example:

Instead of stating that a chosen option is not available, state that the chosen option is available *after* certain required work. This will help the user establish a positive attitude towards the system.
Effective feedback needs to be presented at the proper pace and should be tailored to the specific user situation.

Cognitive Processes

The world around us communicates to us by sound, colors, shapes, signs, symbols, etc. This ongoing communication between the 'world' and humans facilitates cognitive processes like perception and the storage of information in our memoryand the retrieval of it.
In the next sections will be discussed this particular cognitive processes with relation to the design of multimedia systems.

Perception and pattern recognition

How many times have you recognised telephone callers from their very first words? We can often recognise a musical piece from the first few notes. Sometimes we can identify a friend or relative from a cough or a footstep. And from one quick look at a computer screen you know someone is working with Windows. In other words: people are very good in recognising patterns.
People are capable of recognising familiar patterns almost instantaneously. At least two things about the examples above are striking.
First, recognition occurs almost instantly. Second, we seldom make mistakes.
Patterns do not have to be analysed to be interpreted. We do not analyse a face in detail but recognise it at once. The face is perceived as a whole and instantly interpreted.
When designing a multimedia system you will benefit from using the principles of pattern recognition. Designers already benefit from the fact that humans are good pattern recognition 'machines'. The use of icons is an example (the pictogram will be understood as a pattern computer users recognise immediately) , and also the use of multiple windows (each window represents a pattern).
In many more design situations you can make meaningful patterns. For example:

- Organize data to be shown in easily perceivable patterns.
  For example, use a bar-graph to present data instead of a pie-graph. The bar graph gives a better 'pattern' , because the differences between the data will be perceived at once, while a
  pie graph needs more mental activity to interpret.
- It will also help people to perceive information when you present lists in an orderly way. Make distinctions between the columns in a list by using white spaces. Each column will be perceived as a pattern and will be recognised immediately.
- When you have to present long text on the screen, divide the text into paragraphs using white space between them. Avoid too much text on one screen page, because this will hinder the recognition of a pattern.
- And when you design several windows, each with different functions, make sure that the patterns of information and fields are different between these windows. This helps the user recognise immediately the right function in these windows.

Finally, be consistent in presenting information. The more consistent something is, the easier it is to see patterns within it and hence its structure and characteristics.

Mistakes in perception

Most interaction with a computer system starts with visual perception: the computer user locates a menu selection, an entity to be deleted, the cursor or he recognises a form or shape. Unfortunately, people can be wrong in interpreting what they see. Most famous in everyday life, are the witness statements of how a traffic accident happened. Often, different witnesses have their own story about the accident, confusing the police. The explanation of this is that people tend to see what they would like to see or expect to see.
What we can learn from this is that people make mistakes in perceiving an user interface. Maybe they do not notice status-information, or they interpret messages, pictures, or processes wrongly. They will have problems in reading codes and unfamiliar abbreviations.
So for users to perceive the system well, information must be:

- As familiar to the user as possible,
- Legible: the text does not flicker and is easy to read at a glance,
- Distinguishable: the figure is clearly separated from the background,
- Comprehensible,
- Uncluttered, and
- Meaningfully structured.

Furthermore, to minimise the use of unfamiliar codes and abbreviations, one should make schematics and pictures as clear as possible to allow the user to recognise and understand them at once.

Perception and colour

Colour Perception
The challenge for the artist is to capture colour in a form that creates mood and atmosphere. For the interface designer the challenge is to use colours as a form of coding to display information in the most efficient way. Unfortunately, many designers new to colour graphics have tried to become artists. The result has often been disastrous: a mismatchof colours which constitutes neither a masterpiece nor an effective interface.
There has been a tendency to use as many of the available colours as possible in user interfaces. Moreover, there has been a preference to use highly saturated colours based on the underlying assumption that 'the brighter the better'. But if you ever looked at some of the original videotex pages on television you will know how garish such a display can be. Sometimes it is almost impossible to extract the information required.

Colour functions
Colour is most powerful for search tasks and of little use in tasks requiring identification, categorisation and memorisation of objects. In comparison with achromatic coding (black and white), colour has been shown to be of more use in search tasks for inexperienced users than for the experienced.
Colour is a very powerful way to divide a display into separate regions. Hence segmentation of a display for detection and search tasks is very useful. Areas that need to be seen as

belonging together should have the same background colour. Too many colours will increase search times, so colours should always be used conservatively.

There are different psycho-physiological theories about the use of colour.

Below is a summary of some key points that will be helpful in designing user interfaces:

- Looking at colour screens is less tiring for the eyes than looking at screens with no colours. If it is possible to use colours, use them!
- It takes fewer eye-scans to locate objects correctly coded in colour than those coded by other methods. Use colour to mark objects!
- For most applications four to seven colours is the maximum suggested number on a screen at one time. The amount of colours depends on the application. A multitude of colours may be valuable in a virtual reality design, where as in text the use of too many colours can result in an overwhelming and potentially confusing presentation. We advise you to use no more than three colours for text.
- No clear evidence exists to suggest what colour should be used in presenting text.There are a number of claims that yellow (on a dark background) is the best colour for display characters because the eyes are most sensitive to its wave length. This seems true when the eyes are adapted to a typically lighted environment. When people are working in a dark environment the eyes are more sensitive to colours at the lower end of the visible spectrum (blue-green range)
  To make the best choice you have to find out in what type of environment people are working with the Multimedia system! Other studies about the use of colours on a dark background indicate that reading performance is better on *yellow, magenta, cyan and red, rather* than green and blue.
- In general, the best way to use colour is:
  Background:
  - cool, neutral, pale colours
  - Cool colours (blue and green) make objects look smaller.

  Foreground:
  - warm, bright, strong colours
  - Warm colours (red and yellow) make objects look 'bigger'.
- Many colours have some symbolic value in society. Red is used when danger occurs, or for something that is not accessible. Green symbolises nature and environmental issues, but also safety or a go ahead condition. Be aware of different meanings of colour in other cultures. For example, Eskimos have more perceptions of (and names for) 'white' than western-European countries.
- Computer users can link items more easily when they have the same colour. This means that colour related items can not be used for other purposes at the same time.
- About 8% of the male population are colour blind, they are unable to distinguish between various colours, especially green and red. This is important to know when designing a system. It also means that you have to complete some tests involving colour blind people!

Perception and 3 dimensional aspects

The world appears to us in three dimensions. This allows us to see depth and perspectives. Since people are used to the perception of reality, one of the most effective user interfaces design techniques is simulating 3-D interfaces.
Three dimensional interfaces enhance the perception of affordances. The affordances of an object refers to its possible functions. A chair affords support whether for standing, sitting, or the placement of objects. A pencil affords lifting, grasping, turning, poking and of course writing.
In design, the critical value is perceived affordances: what people perceive the object can do (in multimedia systems: icon, button, menu bar, etc.). We tend to use objects in ways suggested by the most salient perceived affordances, not in ways that are difficult to discover (Hence the fact that many owners of electronic devices like videorecorders often fail to use some of their most powerful features. They often do not even know of their existence).
You are probably aware of the next examples:

- Buttons are lumps to push on
- Data entry fields are holes to put things in.

Graphical User Interfaces (GUI), using (overlapping) windows (like pop ups), simulate this 3-D perception. If there's not a GUI-environment available in your project, or if you use only presentation material (slides, Powerpoint application), you can benefit from the following perception insights about 3-D.

Size
If two examples of an object are considered to be roughly the same size then the smaller one appearing on a 2-D surface is perceived to be further away than the larger one.

Interposition
If one object partially obscures a second object then the blocked object is perceived to be behind and beyond the blocking object.

Shadow
Shadows cast by an object provide some cues to the relative position of objects.

Texture
As the apparent distance increases, the texture of a detailed surface becomes less grainy.

Motion
Objects that are further away appear to move more slowly than objects that are closer. This effect is one of the most important cues that enables us to perceive distances and depth.

Memory and multimedia design

Memory is one of the critical limiting factors of human information processing which affects the design of multimedia systems in many ways. I will discuss two aspects of memory : the storage of information and the retrieval of information.

Storage

The concept of human memory consisting of a short term and a long term memory is of course well known, since computers also have a RAM memory (short term) and a hard disc (long term).

From the theory about short term memory we know that it has a limited capacity. Psychologists found in experiments that the limit is 7 items plus or minus 2. Items are not 'bytes' but 'chunks' of information. Chunks can vary from simple characters and figures to complex abstract concepts or images.

This means that in a multimedia system the amount of information that has to be remembered by the user has to be minimised (minimum of the number of actions, commands, objects, properties, rules, etc.). If users have to remember information for some time, make sure the total amount of items to be held in memory does not exceed *five*.

Organisation

Because our long term memory (LTM) is structured in a certain way, we are able to retrieve facts, procedures, principles, experiences, etc. relatively fast. This organisation is certainly not structured like the hard disk of a computer. Humans are able to make flexible connections across 'directories', 'sub-directories' and 'files'. The associative power of the brain exceeds far the power of computers.

Our long term memory is organised in several overlapping ways. The basic organisation of LTM is thought to be *semantic*. Data are stored in terms of linguistically based concepts linked together in a highly developed network of meaningful *categories*. For example, if you are mentally checking your vacation outfit and start with your passport, you will continue with other paper work like your driving licence, insurance papers, money, address book, flight tickets, etc. In some way you have made a category of all the paper work. Fortunately each piece of paperwork is related to other categories. For example, the flight tickets are also related to: the airport, the airline, the pilot, tax free shopping, the flight reservation, etc. This means that our memory is not organised into discrete, non overlapping categories, but is organised in a flexible way.

We can learn from this when we design multimedia systems. In your *multimedia design* you have to categorise as many tasks, items, options, and functions as possible in a non-overlapping way. If you design a Graphical User Interface the use of windows directs you more or less automatically in categorisation of tasks, items, information, etc. You should not only categorise menu bar items, but also lists, icons, buttons, data entry fields, etc. You should make it clear to the computer user what relations exist between those categories, allowing them to retrieve information in a flexible way. Also, with your design, encourage users to categorise information which must be retrieved later. Provide prompts, labels or (menu) names which are relevant to those categories.

Memory is also organised in *episodic* memory. In episodic memory we relate a word, an experience, an 'odour', etc. to some event. For example, when you try to retrieve the name of the author of a novel, you recall one evening when you spoke about a book by this author. In your mind you see the table with a glass of wine and the book next to it. You remember the atmosphere of that evening and other features, that brings you to the name of the author. It takes less effort to remember items from this episodic memory. This explains why *metaphors* are used in graphical user interfaces, because they relate activities to human experiences and events.

Retrieval of information

Psychological research has revealed that the retrieval of information from our memory is far better when we can *recognise* stored material rather than *recalling* material from memory. This is why the 'multiple choice' questions in tests are so popular. It is also one of the reasons people like multimedia, including running video, pictures and windowing techniques.
Our ability to recognise information is particularly remarkable for pictorial information. Several studies have shown that our capacity for recognising pictures may be almost unlimited and is extremely accurate.
Psychologists found that *wrong* interpretations of commands occurred far more often when using command names (*text*) than icons (*pictures*). The obvious implications for interface design is that you have to use *recognisable, pictorial* items instead of *textual items* that a user has to *recall* from memory.

Computer systems are very valuable in helping people retrieve information. In fact the memory burden of computer users can be drastically decreased (especially, as we have seen, when they are using systems with a Graphical User Interface), since they only have to recognise icons, menu options, and pictorial information.
Graphical User Interfaces however do not completely decrease the memory burden. People will always have problems retrieving information, even when they are using a supporting computer system. This is related to:

Distraction
When people are distracted during their task performance, they will forget recently learned or stored material. Even a small number of simple 'chunks' of information are lost within 20 seconds if there is distraction during input.
In your interface design you can help people if they are distracted. Users must be able to stop an ongoing process temporarily and users must be informed about the status of the task (status information that answers user questions like 'Where am I?).
If the distraction means that the user has to leave the current task or module, and has to switch temporarily to another task, the user must always be able to go back where he came from.

Interference
Other inputs which impair retrieval are called interference. When you are trying putting some material in your short term memory (for example: some names of clients), and there is at that moment other input you have to attend to, you will have trouble retrieving the former material.
Supplying irrelevant material during input to short term memory makes retrieval more difficult.
This means you have to present one task at the time in the Multimedia system. If you can avoid it, do not confront computer users with other inputs at the same time!

Primacy and Recency Effect
Psychological experiments show that when people have to remember information, the last items of the received information are best remembered *(recency effect)*.
The middle items are poorly recalled, and are even not recalled when there is a lot of information. The remembering of the first items, however, is also very good *(primacy effect)*.

This means that in presenting information to the computer user (e.g. text) the most important information has to be presented at the end (or at the beginning). For example present explanations of how something is working in the middle, but present the concrete 'how to do' things at the end.

Conceptual Metaphors for the Visualisation in Interactive Learning

Piet Kommers

Abstract

With the arrival of the full spectrum of presentation modes in computer-based learning resources, it becomes urgent to review already existing theories about visualisation and animation as defined for paper-based publication, movie and video.
One of the differences between traditional media and hypermedia is that the first ones take the user along in a consistent sequence of episodes that refers to a lay-out, story or scenario that can be understood and in some way or another 'be predicted' from cultural experience and prior knowledge. Hypermedia in contrary allows the user to jump away from a current piece of information to a certain aspect which is only an arbitrary detail of the previous scope. Text-based hypermedia (called hypertext) allows the user to browse via concept identity. This means that a term in an explanation can be exploded by clicking the location of this term (called hot spot). The same term will appear at the top of the exploded view, and will also be the key issue its content. The concept identity is the fact that the term in the clicked hot spot is identical to the subject of the exposition in the exploded view. Browsing through pictures, video and sound elements allows the user to zoom in on details. However it is quite complicated to guarantee some kind of concept identity in the transition from one picture element to another. The reason is that picture elements are less self-contained than words in a text. The context dependency of visual elements causes surprise and confusion in the user. One way to solve this problem is to enclose meta-information with the visual representation which links different views with concepts that are present at both sides of the link.
Hypertext links can be visualised in a concept network, where the nodes stand for concepts. The concept node represents the identity between hot spot and the key issue in the subsequent exploded view. Generalising the concept network to picture transitions can be done by prompting clusters of elements and labelling them with a concept term. The choice of clusters and the term will orient the user to the type of digression he/she may expect after clicking a certain hot spot.
Conceptual overlays in audio and video segments presuppose a moderate level of granularity; The overlay should remain valid for a minimum time span so that the user can anticipate his browsing direction while seeing the next fragment. This can be done by having the hot spot elements at static positions in the screen, while the moving elements settle the context situation in which critical concepts arise. The conceptual metaphor for effective use of hypermedia constitutes schematic representations which is an accentuation of the meaningful elements the user should be aware of while browsing through unknown information. At the same time it might function as an epistemic analysis for the hypermedia designer who needs an explicit content description in the design phase.

Introduction

Computer-based learning programs have triggered again the basic discussion on didactic strategies, styles in learning dialogues and the design of information elements like text , visual images and sound. The key element in this revived debate is the notion of 'self-control' for the student versus the attempts to facilitate learning by regulating the learning process by pacing and sequencing information elements and systematic remediation of evolved misconceptions in the student's mind. Hypermedia and multi-media were quite welcome after twenty years of high expectations of 'advanced programmed instruction', 'intelligent tutoring' and 'student model-driven dialogues' Rather than stimulating the traditional opposition between student- versus system control its seems more productive now to unify them by asserting that hypermedia explorations might serve complementary stages in learning and instruction. Initial stages of learning in which pre-cognitive levels of expertise and intuition in the student are mobilized, versus the need for a more controlled instruction facilitating a later, more operational stage of learning in which correct task performance plays an important role. This chapter presents the merits of recent visualisation techniques in pre cognitive learning stages while using hypermedia. Essential for the cognitive benefits in this stage are the so-called metacognitive effects, Balajthy, E., 1990 and Cates, W., 1992.

The availability of pictures, sounds and video in electronic learning material brings the opportunity to confront the student with flexible realistic views in a certain domain. Especially as competing media programs like television commercials with astonishing video clips, animations and highly suggestive and condensed social episodes penetrate, it is quite urgent to make interactive learning programs as expressive as possible to elicit emotions and keep the attention of the user.

The user flexibility of hypermedia gives full control on sequence, focus and perspective to the learner. While hypertext browsing has become popular quite quickly, hypermedia browsing is still rare. One reason for it is the amount of effort to prepare the numerous transitions and necessary visual consequences that should be anticipated. Another important complexity is in the inconsistencies that may arise when allowing the user to browse between visuals, sounds and video fragments. The chosen solution to overcome ambiguous transitions between pictorial elements is to superpone conceptual structures on the candidate hot spots. Before going into the techniques of concept representation, - metaphors and interaction procedures, let's review already existing theories about visualisation and animation as defined for paper-based publication, movie and video.

Words, Images and the Level of Abstraction.

'Words and images cannot be derived from each other, ...' Foucault, 1966. It stresses the uniqueness of human senses. Quite typical prehistoric tribes reflected their desires and fears in pictographic images. After centuries however they moved to more abstract cryptic symbols representing objects but also feelings and reflections. These symbols did not necessarily resemble the objects they referred to. A separation between reality and mental representation. Words like symbols do not necessarily refer to one concrete object or situation, it may also point to a more general unity of things. Words like

'cattle' or 'agriculture' are typical generalised concepts in the sense that they 'pack' a set of more specific concepts like 'cow', 'deer' etc.

Figure 1

Figure 2

The typical difference between word and image is that words do typically tend to express generality and tend to neglect individual perceptions, while images do defacto point to specific elements of reality. The trade-off for hypermedia designers is to take the advantage of words, tending to tell the most general impact of their meaning, or images which seduce the user to the uniqueness of a certain element. General concepts like 'inflation', 'responsibility', 'entropy' or 'inertia' are difficult to express in static images. If we try to do so as they can hardly express conditions like 'sometimes', 'only if ....' etc. and it brings the user in the danger of picking up irrelevant or even uncorrect attributes in the visualisation of the key concepts. At the other hand images can sketch a typical situation quite rapidly by triggering perceptive templates that we as users know from past experiences. Above the so-called 'scheme-activation', images, sound and video have a strong appeal to the imagination of the perceiver. Spatial and episodic consequences of the scenery can be generated and remembered for a long time. Conflicts in pictures can be detected quite easily, as the human eye has been trained for many years. One could even say that the human brain is especially equipped to interpret reality from social and visual messages. The picture with the bed scene in figure 3 is ambiguous in many senses, but several hypotheses can be rejected by the observer immediately. The perceptive and interpretative effects are quite dependent from conflict elements in the image. Archetypical features in the outlook and character of actors make it easier to arrange a conflict in the scene. Conflicts arise emotions in the spectator and makes it easier to catch the attention for a longer time. Learning effects will only take place if the arranged conflict is anticipated by a question or open interest in the user. The first of the two next pictures will hence evoke a longer attention from the viewer and will also be processed at a deeper level. As a consequence it may be expected that the picture in figure 4 will be remembered for a longer time, compared with the picture in figure 5 which causes less arousal at the spectator.

Figure 3

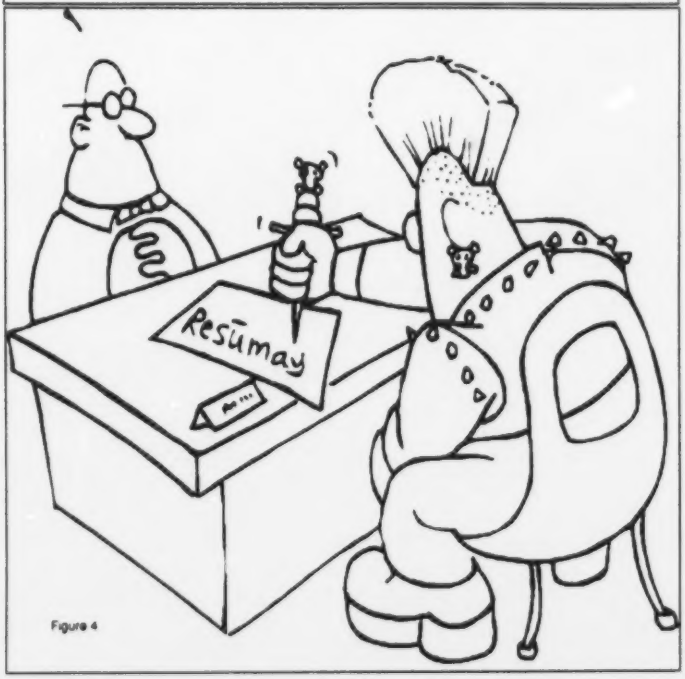


Figure 4

As one tries to explain the difference in examining figures 4 and 5 it makes sense to distinguish between 'understanding' (coping with the meaning of a certain impression) and 'remembering'. It is generally assumed that meaningful processing facilitates remembering. Semantic processing for instance is assumed to be more effective than formal processing, (Jenkins, 1974). Increasing the 'depth' of processing will produce better memory (Craik and Lockhart, 1972, Craik and Tulving, 1975). The key issue is to arrange the images so that they actually trigger emotions, imagination and personal experiences from the past. As culture changes quickly, and persons differ quite a lot, it is hard to find overall guidelines. The urgence to chose the right elements in visuals is clearly demonstrated in the effort given to commercials.

Trade off Between Abstraction and Concreteness in Presentation.

So far the global distinction between visuals and audio (perceptual) at one side and verbal or written information (conceptual) at the other side has been made. While hypermedia designers are steadily improving the flexibility and expressiveness of browsing, the more fundamental question arises to what extend we might expect beneficial cognitive effects for the user. A dominant criterion so far is the level of excitement and entertainment. The more exuberant presentations, inclusively three-dimensional impressions and direct manipulation in space, the more is the appeal to the user.

Besides the alertness on cost-effectiveness it becomes important to find a rationale for the learning criterion that might decide upon presentation richness. Edgar Dale took up the concept of 'realism' of Hoban and Zissman (1937), and laid it down in his 'Cone of

Experience' Dale's ambition is to adapt the realism and the level of user interaction during media presentations to the momentary user's level of cognitive development and competence. The trade off has to be made between the conciseness of information, which is typically appropriate if the student can read and understand scientific expressions, mathematical formulas and pictographic symbols at one side, and more elaborate experiential situations which cost more time and instructional effort, but which will compensate lacks of prior knowledge and which will allow the student to learn by experience before any formal instruction takes place.

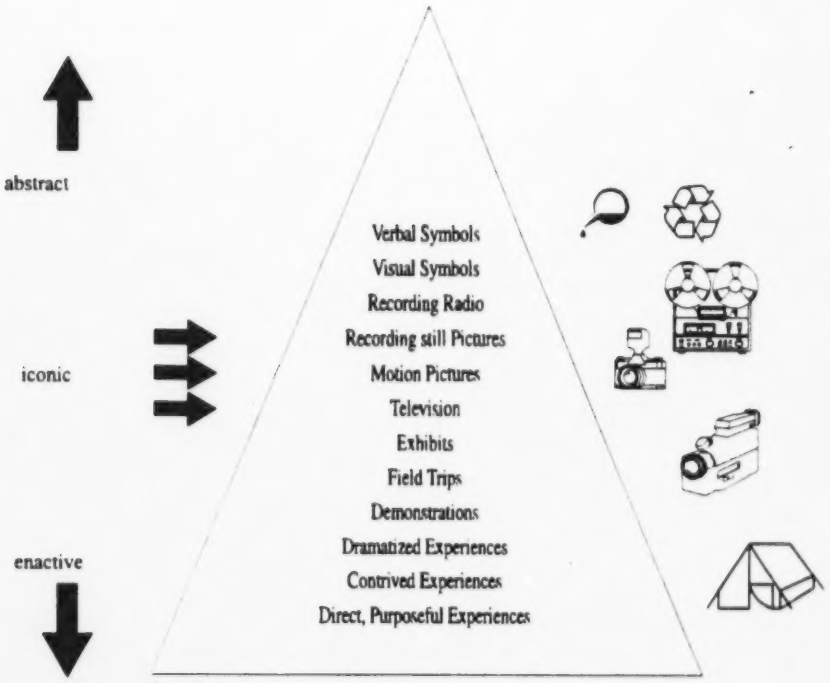


Figure 6

Dale's notion on levels of presentation goes beyond the question how to visualise. In fact it addresses the issue of interaction style and instructional strategy. For hypermedia design we can use Dale's cone to decide upon when to invest in full motion video, still video, sketches, the combinations with audio, or visual and verbal symbols only. As many student characteristics are hard to assess during or even more difficult before a learning session, hypermedia presentations might be superior to prepacked CBL sessions as they leave essential choices about the modality of information to the user. Based on cognitive style, prior knowledge or momentary interest the student may ask for presentations at a lower (more concrete) level. It may even be the case that the student at a certain moment wishes to interrupt the presentation and asks for a confrontation with a simulation environment in which so-called 'what-if' experiments can be done

Concepts, Objects and Visual Representation.

The idea that one can think in images is not as strange it sounds. Of course its validity is quite dependent upon our definition of 'thinking'. Many of the human actions are directly based on what we see, hear and smell. The resulting behaviour at those mentioned moments is controlled by a very fast cycle between perceptions, emotions and testing our feelings by taking a perspective for new impressions again. Abstractions, reasoning and conceptual change occurs hardly in those situations. This is the very reason why certain social behaviour and emotional reactions are hard to change. It is this pre-cognitive aspect that plays an important role in the effects of visualisations. At one hand we should be aware that images and sounds trigger a fundamental layer in the user/learner, while at the other hand we know from research that they are most effective to consolidate the process of knowledge acquisition and conceptual change. The user of a hypermedia system may benefit from a flexible access to different visual representations so that we might describe this browsing behaviour as operating a camera: Panoramic view, zooming in, zooming out, filtering, jumping back etc. If the information nodes and links via hotspots have been defined from a didactic perspective however, we might expect that these perceptual transitions finally promote mental views which are more or less congruent those of the experts who prepared them. The central discussion about hypermedia as learning resources is to what extent explicit conceptual arguments should be added to the browsing space, before effective learning takes place. This discussion is both relevant for optimising hypermedia for the pre-cognitive stage of learning, and for the integration of hypermedia in more controlled instructional episodes as well.

Let's imagine the domain of combustive engines and see how visuals may facilitate cognitive stages in understanding, generalisation and problem solving. It's hard to imagine how difficult it would be to teach the typical characteristics of a diesel motor to someone who never saw, smelled and felt the movements of a running diesel engine. Not knowing the physical and mechanical principles of a combustive engine, one will still derive quite important aspects of the combustive mechanism by seeing, hearing the effects of such an engine built in a car, boat or train. Having observed the starting process of combustive engines gives already the notion that certain conditions must be met before the process starts running. E.g. the effect of temperature, the speed of the rotation and the degree of choking and giving throttle.

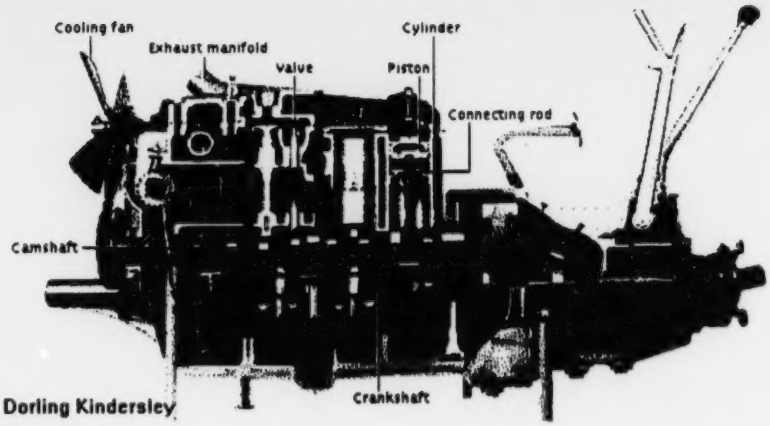
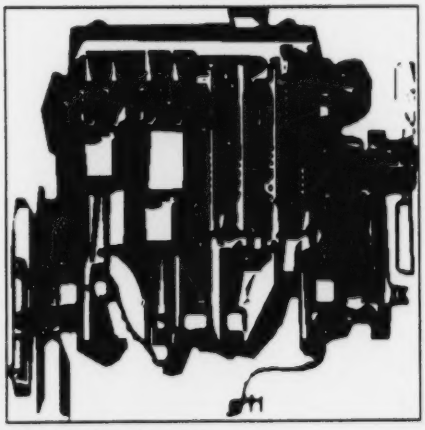
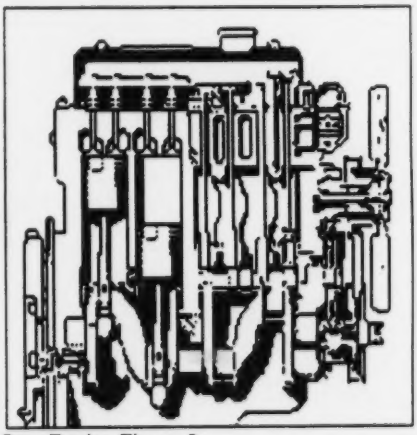


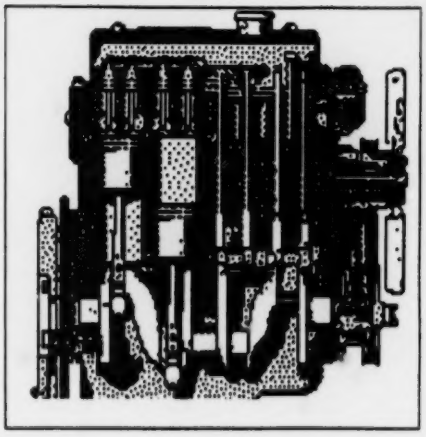
Figure 7

However most of the even very successful car drivers do not know any formal aspect of the combustive mechanism. Even after many years driving, these perceptions and experiences are not sufficient at all to build up a correct idea what happens in the motor itself. To acquire such knowledge is exactly the typical task for education and training. In terms of Dale's cone of experience it is the question then to migrate tactically from perceptual confrontations with the phenomenon of combustive engine up to more conceptual representations so that flexible knowledge may evolve.


Otto Engine Figure 8


Otto Engine Figure 9

The three images and caption text of the combustion engine are clipped from Microsoft's Encarta Encyclopaedia on CD-ROM.



Early Internal-Combustion Engine
One of the most important inventions of the mid- to late- 1800s, the internal-combustion engine generated mechanical energy by burning fuel in a combustion chamber. The introduction of the new engine led almost immediately to the development of the automobile, which had been largely unfeasible with the unwieldy steam engine. Shown here is a 1925 Morris engine, the basic unit for a family car. It features four in-line cylinders with aluminium pistons. The valves are opened by push rods operated by a camshaft and closed by springs. Power is transmitted by means of the crankshaft to the gearbox. (By: Dorling Kindersley) Otto Engine Figure 10

The displayed opened engine takes place in an animation sequence to illustrate different periods in the Otto-cycle engine, named after its inventor, the German technician Nikolaus August Otto (1832-91). It is the familiar gasoline engine used in automobiles and aeroplanes. The diesel engine, named after the French-born German engineer Rudolf Christian Karl Diesel, operates on a different principle and usually uses oil as a fuel.

The first image (Otto Engine Figure 1) gives quite a global impression of the overall shape and is quite close to a pictographic representation. The global components are visible, only to attend global positions of the crankshaft and two of the pistons. To illustrate the interrelated positions of the crankshaft, piston rod, piston and valves, the front view is more appropriate as it gives a natural argument to display only the constellation in one of the four cylinders.

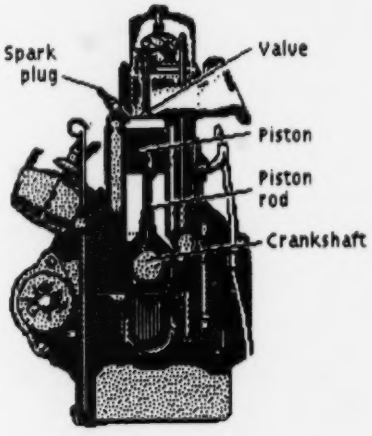


Figure 11 **Front view**

Figures 8 to 10 displaying the Otto Engine with an increasing level of detail illustrate the capability of current drawing facilities in graphical user interfaces to prune away successive levels of details, even in bit-mapped images. The potential opportunity of these various smudging levels in hypermedia presentation is that we might confront

students with pictures that are automatically filtered from details just above to the level of understanding at that moment

Computer-based Adaptation of Visual Images

As more tools for image processing become available, it becomes easier and challenging for courseware engineers to prescribe adaptive levels of detail in didactic images. The next two pictures of arch fences start quite differenct reactions in perception, interpretation, generalisation and retention for the user. Figure 13 has been derived from figure 12 by means of Corel Draw's 'tracing' facility.

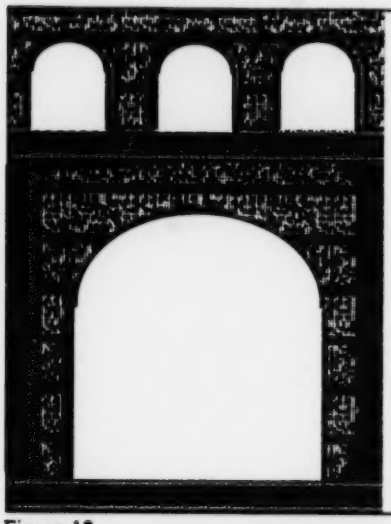


Figure 12

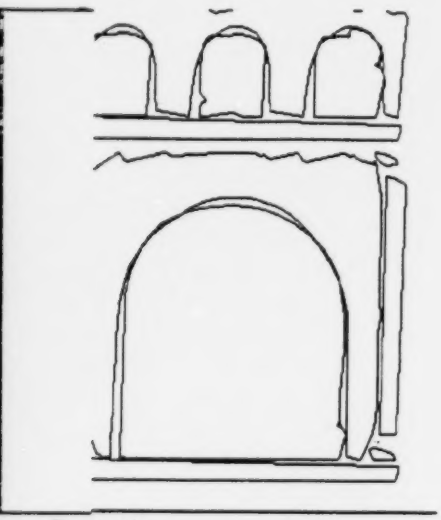
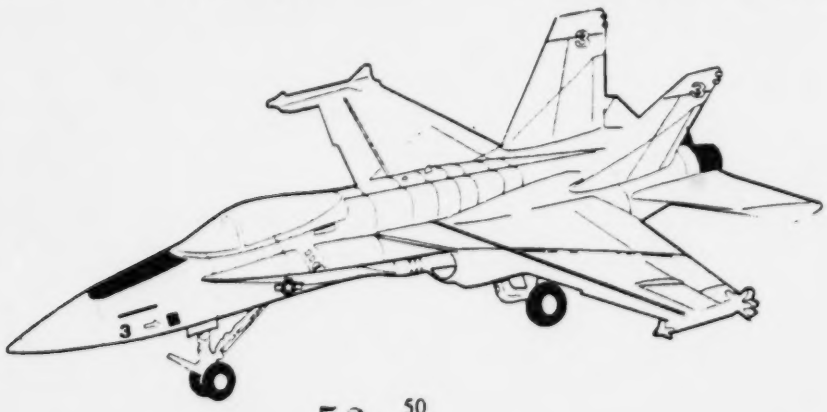


Figure 13

To illustrate the technique as used to change Otto Engine Figure 10 into 9 and finally into 8, the bitmap image of the three arches above is used to trace its contours and finally drawing the attention of the user to its major components, hiding the structure of the bricks the fall of the light etc. Essential however is that the final trace image



keeps the impression of a real object, with small vividness in its lines so that it activates the imagination of the spectator. Visuals, composed of purely geometric elements miss this suggestion and though they suggest more exactness, they lack the appeal to the human mind. Finally the contour image in figure 13 costs only 200 times less storage space and can be drawn in a fraction of the time compaired to figure 12. In fact this contour sketch can be handled as an object image, which is easy to colour or to rescale based on an actual presentation or instructional arguments. In terms of Dale's dimension of contrived versus real experience it is obvious that the contour image is situated more closely to the symbolic level, however it keeps a stronger reminiscence to the perceptual image of the photograph by its suggestive details.

Bit mapped images are difficult to manipulate in a meaningful way, as there is no information about its components. Object images can be filtered, cropped and distorted based on semantic criteria as long as the names of its labelled parts are compatible with the descriptions of its functions and relations to the presentation arguments like speed impression, articulation of perspective etc.

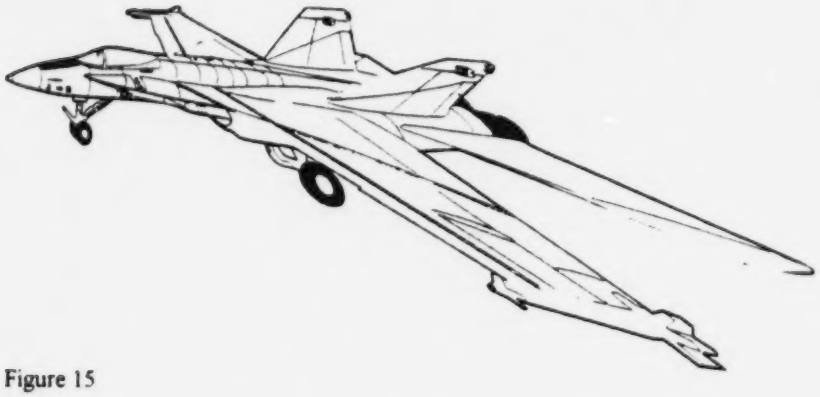


Figure 15

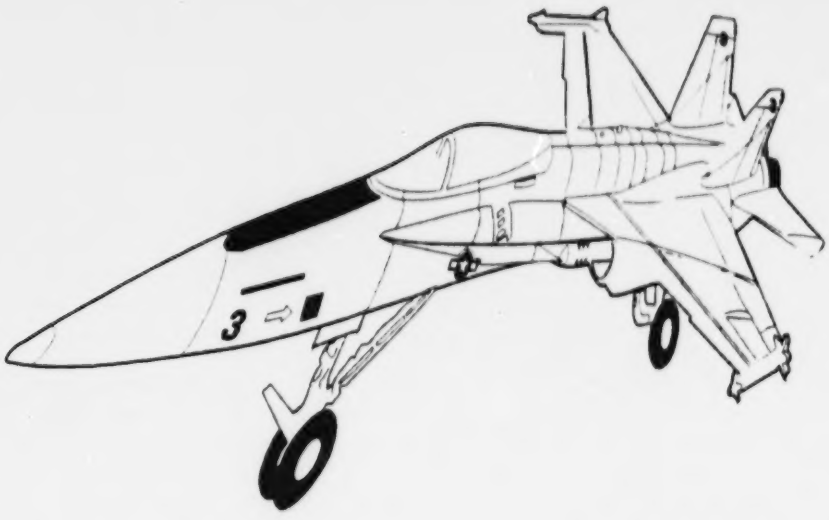
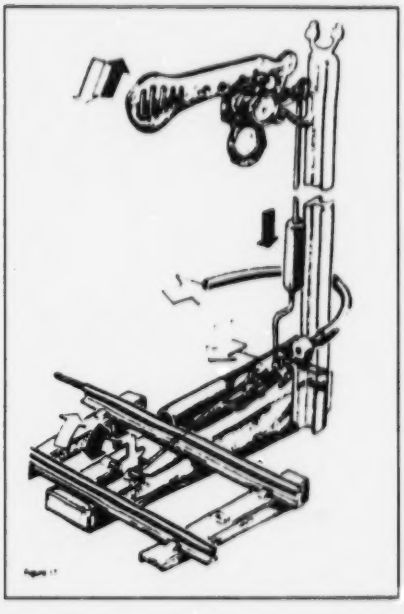


Figure 16
Object oriented visualisations permit the hypermedia designer to be more expressive in the functionality of certain objects and to change easily between certain cognitive perspectives elicited by display arguments as shown before. The display of the pneumatic train semaphore (figure 17) gives a rudimentary impression of its working. The human eye however needs a longer time to detect the mechanistic elements like the airtubes, the cylinder, the piston and the final drive mechanism of the switch staves.



The help of arrows to indicate the direction of movements and the cut and opened parts ask quite an effort of the visual designer to reduce the complexity while keeping the picture appropriate for different levels of expertise in users. Changing the function of the display in the explanation chain needs a laborious redrawing, and of course it cannot be generated automatically by a computer program. Is easy to see that one of the major options in using object-oriented pictures is in the pick-and-mix facilities, enabling hypermedia designers to include precisely defined elements of other pictures in new ones

Let's focus on technical drawings like those to explain maintenance personnel where to find certain elements or to prompt them in which order procedures should be performed. These drawings need sufficient details in certain parts while they may be global in the peripheral zone. Good examples can be found in repair manuals for the car dealers.

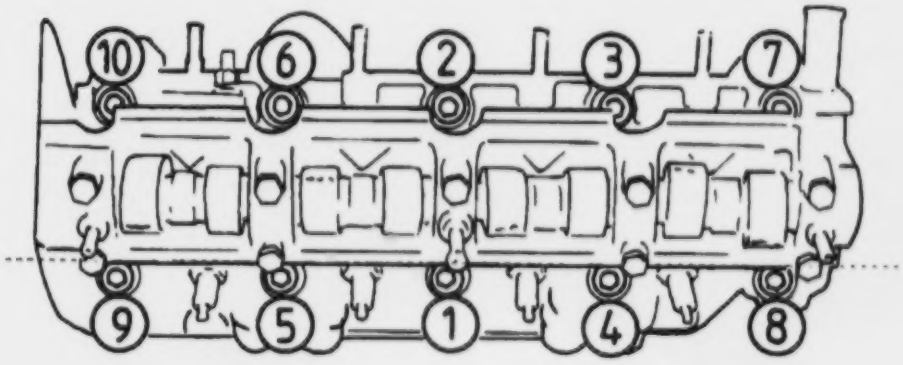


Figure 18

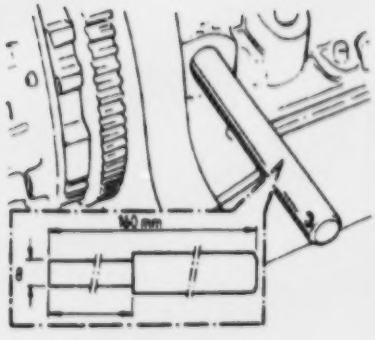


Figure 19

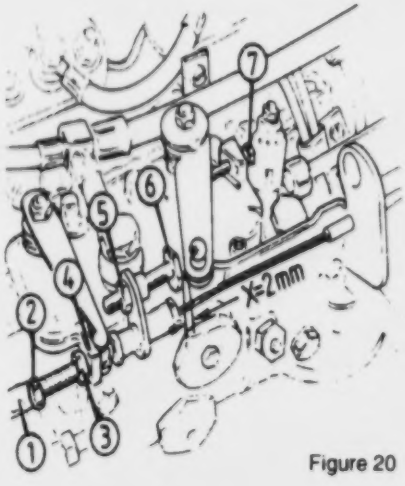


Figure 20

Within the scope of a certain assembly action like tightening the bolts through the cylinder head (figure 18), a drawing is made so that it servers as a direct orientation for the operation to be performed. The location and relative positions of the bolts have been drawn quite precisely, while the surface of the motor head is only suggested vague. A more delicate action to be expressed is the adjustment of parts, as shown in figures 19 and 20. Especially in the last two examples it it obvious that one has to find

a balance between the clearness and convenience of overview at one side and the wish to combine different actions in one picture at the other side

Concept exploration by visual negotiations

Visual images may play an important role in concept formation, especially if the application domain is visual. If the concept space is more abstract, concept mapping techniques can be useful to express global entities as a framework for elaborations later on. Concept mapping has become popular in learning, design and problem solving. The underlying idea is that the schematic representations give the user a greater flexibility while searching for creative solutions. Graphic representations rather than oral and written words enable to express the simultaneity of ideas in one stroke. Concept maps are mostly drawn in twodimensional space. For more dense networks, a third dimension may help, especially to distinguish between fore- and background. The negotiation metaphor is well known for learning purposes and says that students should not simply be receptive for new information, but they should be placed in the position of a stakeholder who faces the trade-off between changing him/her self (by internalising the new concepts) or by analysing the new ideas for their structure and reformulate them so that they fit in their actual state of knowledge. The first approach asks for a better memory while the second heavily relies on reasoning and detecting analogies. The concept mapping technique as a negotiation tool for evaluating these two strategies can be intensified by introducing 'spatial impossibilities' like present in the well-known paintings of Esscher. The two images below place the spectator in a mental conflict. He/she has to decide upon fore- / background positions based on the content in the nodes (placed on the edges of the figure).

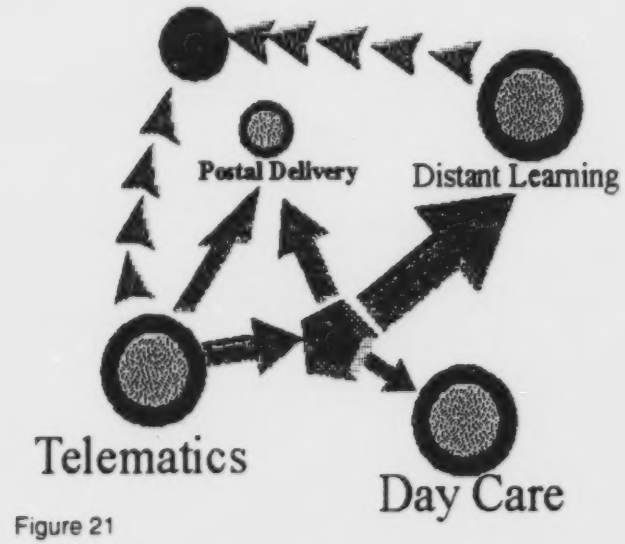


Figure 21

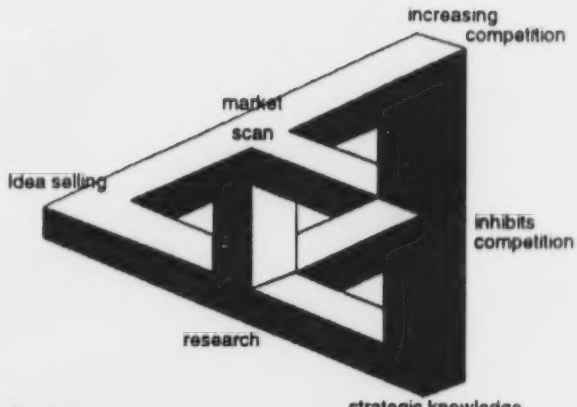


Figure 22a

The choice should be effectuated in dragging the concept terms so that he spatial connotation looses ambiguity and reflects the semantic implication as well. The cognitve benefits of provoked mental conflicts will only emerge if the student is trained and motivated for a certain level of cognitive flexibility. If we regard the typical atmosphere and discipline in educational and training setting we see the opposite tendency. Students are trained to assimilate prestructured views and opinions. However many students face massive uncertainty if they meet realistic problems they have to solve, because they don't have fitting solutions ready to apply in their memory. So for creative jobs like design, human managment, boundary spanner and trouble shooter it is obvious that cognitve flexibility is a defacto attitute, that should have been stimulated in the early phases of learning.

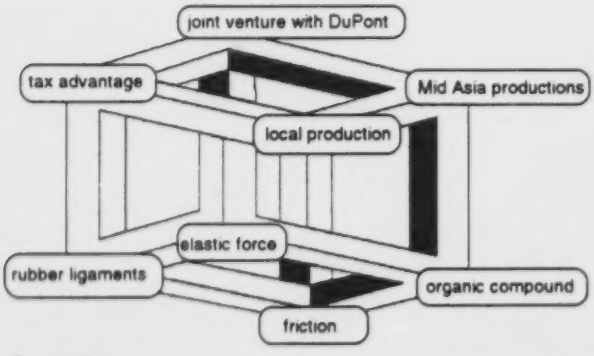


Figure 22b

Spatial connotations of concept relations have been worked out by researchers quite intensively so far. The basic assumption is that human knowledge cannot only be scaffolded by verbal concepts, but need a more perceptual and experiential representation for several reasons. Computers may help in realising the manipulation

and reconciliation between the user and his/her conflicting mental perspectives. In fact the visualisation here works as a provocation to the user who will strive for equilibrity between knowing, feeling and seeing. The perceptual conflict as demonstrated above can also be extrapolated to an operational one, in which the user has to compete against 'primitive' intuitions how to achieve a certain spatial effect. Let's take a simple spatial, conflictless design tool for concentric objects before going into an example which may illustrate provocational situations for travellers through concept space.

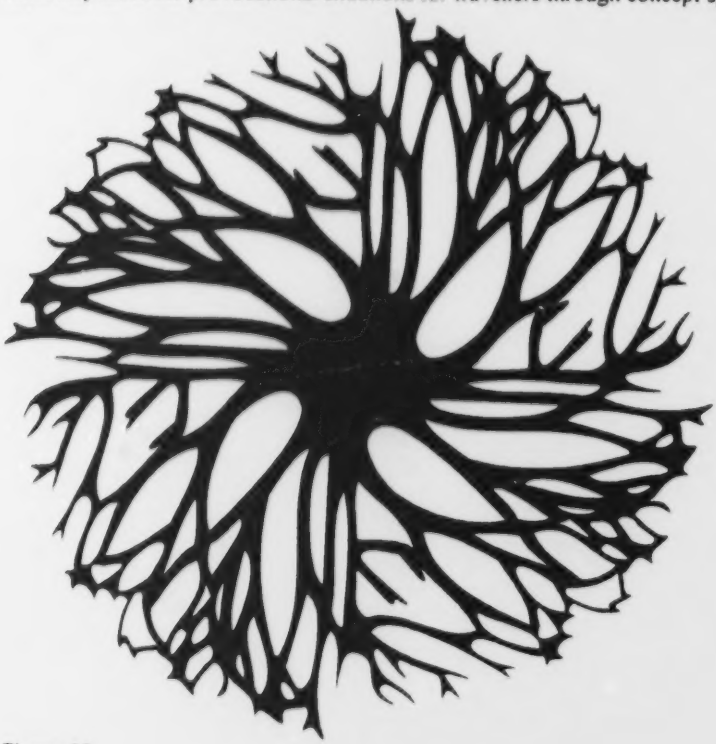


Figure 23

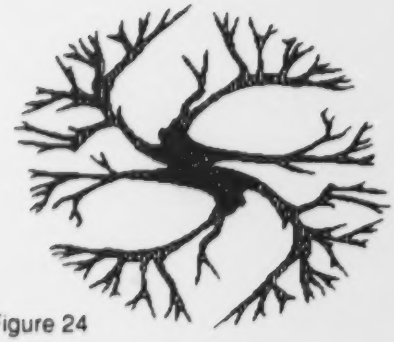
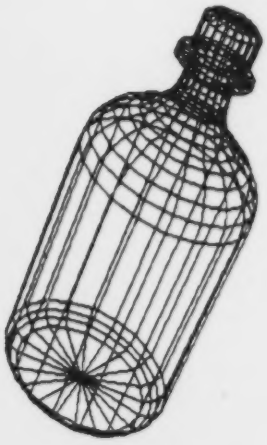
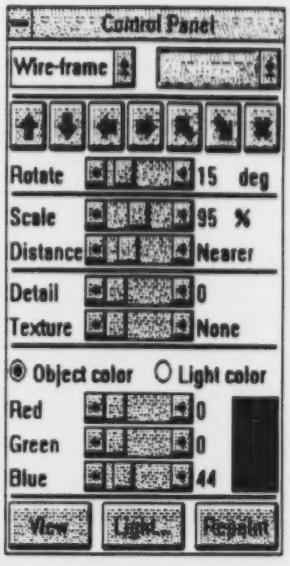


Figure 24

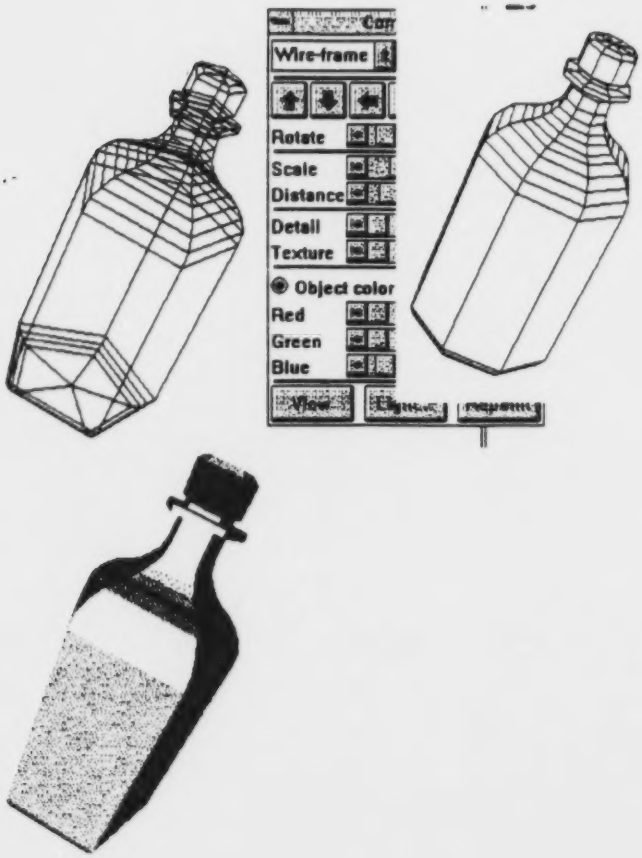
To show how we as perceivers are bound to 'common views' try to identify the next image. Where can you find this object? If you have problems finding the answer, try to make assumptions about the genetic element of this object: How did this shape evolve from the centre part? Why is the density of smaller elements higher at the outside of the object?
If you still have problems, please study some of its substructure in the next picture.

Probably the organic structure in the centre of the figure acknowledges your initial idea that it has to do with a tree. However the trunk fails. If I ask you: "O.K. it is a tree, but where can you find such a strange shape of a tree?" You might start some reasoning and find out it must be the top view of a tree. This is correct. This puzzle illustrates that the third dimension can easily confuse your normal reference to reality if not appearing in conventional situations or from conventional angles. This weak part of human perception can be used to amplify cognitive uncertainties which are very important in thinking, learning, decision making and design. Just like perceptual tasks, cognition needs exploratory situations where we can discover the constancy in our relation to reality by experiments. For instance it is a good practice to imagine cutting planes if you like to become aware of complex shapes.





µLathe (MicroLathe) is an easy to use modelling tool that allows you to create three dimensional objects using the metaphor of the carpenter's lathe. The number of slices may be chosen and one of the display methods as well. the wire-frame is the most rudimentary one. Hidden, constant and Gouraud give an increasing level of spatial and light-reflective realism.



The different outlooks of the lathing procedure can immediately be viewed and controlled for certain conditions of light and rotation. The lathing metaphor enables the user to explore the relation between lathing curve and its final effect in 3D space. It illustrates perfectly the functionality of CADD technology (Computer Assisted Draft and Design). It is not only effective for the designer of visuals but especially adequate for students who use it as an exploratory tool for spatial awareness.

Conclusions

This chapter has raised some didactical opportunities which may benefit from graphical and spatial manipulations by the student. Browsing through visual images in interactive learning material until now is restricted to simple actions like panning and zooming like present in current CAD and drawing packages. Visual representations in computer systems allow the user to explore spatial perspectives in order to acquire a better understanding of physical objects, machinery and constructions like architecture and design.

Before flexible and meaningful visual transformations become possible it is important that pictures are vectorized along at least three dimensions. The fourth dimension (time axis) becomes important if it concerns an animated process, like important in explaining the four strokes of a combustive engine.

Adding semantic relations between the components in a visualized constellation like an engine, electronic device, or an organic body can will even allow the student to explore its functionality as he/she changes the position, the size or even the shape of elements, after which the consequences in functionality will be displayed, like e.g. the temperature, current, concentration, speed, friction etc.

The ultimate benefit from interactive visuals might even go beyond the spatial and mechanistic orientation. The given examples of 'impossible figures' as carriers for concept maps show that spatial conflicts in pictures can be used to elicit pre cognitive ideas and hypotheses from the student at the beginning of learning sessions in order to provoke an optimal receptive mind for new ideas. Crucial issue in visualisation for learning purposes is the possibility to manipulate, change, combine by the student while the consequences can be seen immediately from the same picture.

References

Balajthy, Ernest: Hypertext, Hypermedia, and Metacognition: Research and Instructional Implications for Disabled Readers. In: Journal of Reading, Writing, and Learning Disabilities International, v6 n2, p183-202 Apr-Jun 1990.

Cates, Ward Mitchell: Considerations in Evaluating Metacognition in Interactive Hypermedia/Multimedia Instruction. 20 Apr 1992.

Craik, F.I.M., & Lockhart, R.S.: Levels of Processing: Framework for Memory Research. Journal of Verbal Learning and Verbal Behaviour. 1972, 11, 671-684.

Dale, E.: Audio-Visual Methods in Teaching. Rinehart and Winston, New York, 1946.

Foucault, M.: Les Mots et les Choses. Paris, Gallimard, 1966.

Hoban, C.F. & Zissman, S.B.: Visualizing the Curriculum. Dryden, New York, 1937.

Jenkins, J.J., Can we have a Theory of Meaningful Memory? In R.L. Solso (ed.), Theories in cognitive Psychology: The Loyola Symposium. Hillsdale N.J.: Lawrence Erlbaum Associates, 1974.

Microsoft Corporation "Internal-Combustion Engine". Microsoft (R) Encarta. Copyright (c) 1993 Microsoft Corporation. Copyright (c) 1993 Funk & Wagnall's Corporation.

Functions and Design of Video Components in Multi-Media Applications: a Review

Pløn W. Verhagen

Introduction

Designers of interactive multi-media applications face the decision when and how to be presented information has to take the form of text, graphics, animation, video stills, moving video, sound, or any combination of the former. This contribution focusses on design decisions with respect to the use of live or animated video segments with or without sound. First, functions and utilization patterns of video as a component of multimedia systems are presented. Next, research on audiovisual design is reviewed with respect to camera factors, audio factors, optical effect and special effects, pacing and rhythm, animation, picture complexity, and using two channels (visual and audio).

Video functions

Video functions may be classified according to content-driven or logistic criteria which may both be used to support decisions to select video as a component of an instructional application. Figure 1 provides a list that is based on Verhagen (1992, 1993). The functions are:

Content-related use of photographic pictures or moving video (showing people and objects). This function concerns the message-specific need for a certain mode of presentation (if I require a visual, audio will not do; and if I have to show motion, video has to be preferred over still pictures). In certain fields, such as medicin, biology, and geography, there are many content elements for which it is self-evident that they need these kinds of visuals. It has to be noted, however, that in many cases message characteristics are not unequivocally prescriptive with respect to communication mode. Visual referents in memory may for instance inhibit the need for pictures, if they sufficiently support mental imagery in the context of verbal messages. Figure 1 shows that content relatedness plays a role in several of the other listed video functions.

Depicting the invisible or the non-accessible. This concerns presentation options that cannot exist without certain media techniques. Examples are: slow motion, time- lapse photography, photography with invisible beams (like Röntgen or infrared photography), use of telescopes and microscopes, and animation. Here the "human size" with respect to perception in space and time is an important factor. Some experiences cannot happen if events could not be speeded up, slowed down, scaled up or scaled down to manageable proportions by use of media.

Logistic use. Straightforward applications concern uses of media to solve problems of place, time, and identical repetition of messages. (In most cases, it is more feasible to show a slide of the Vesuvius than to visit this volcano). And, substantial effort to

develop an audiovisual programme which contains a refined discourse about a certain subject is a one-time investment. (The programme can be repeated infinitely with constant quality.) Logistic arguments apply also in the cases of several other functions, as is represented in Figure 1.

Video functions:	**Purpose:** *Content-related*	*Logistic*
Content-related use of photographic pictures or moving video	•	
Depicting the invisible or the non-accessible.	•	
Logistic use.		•
Cognitive help (visualizations as tools for thinking).	•	
Modelling of psychomotor skills.	•	•
Video feedback	•	•
Providing observation materials.	•	•
Psychologically realistic simulation.		•
Video to present gifted teachers.		•
Video design for emotional involvement.	•	

Figure 1. Videofunctions in relation to content or logistics

Cognitive help (visualizations as tools for thinking). Visualizations may offer new perspectives on knowledge or extend existing knowledge in the way that Bohr's Atom Model shaped thinking about how an atom is conceived. Bohr's model provided a way for insightful communication about the elementary decomposition of matter: a message for which visual media characteristics could be exploited succesfully. Similar reasoning applies, for instance, to the insightful animations (with narration) that demonstrate the essence of the Lorenz transformation or Einstein's Special Theory of Relativity. In general, schematizing is the keyword here.

Modelling of psychomotor skills. Video is in many cases an appropriate means to demonstrate motor behavior.

Video feedback. Video may be used to record student behaviour for feedback purposes. This may support the evaluation of psychomotor performances, feedback during microteaching sessions or interview training, and other.

Providing observation materials. Video registrations (of group discussions, of children playing, of animal behaviour, etc.) may provide opportunities to train observation skills and to learn to analyse behavioural patterns.

Psychologically realistic simulation. Social interaction may be simulated by having human models on -- for instance -- videodisc who react to decisions of students by talking directly to the students from the video screen. Well-known examples are video-based management games.

Video to present gifted teachers. In fact a variant of logistic use, this video function provides the possibility to repeatedly enjoy the presentation of outstanding teachers who demonstrate their skill in handling subject matter.

Video design for emotional involvement. In this case, aesthetic value, emotional value, and use of drama are at stake. Factors regarding pleasure, goodness, beauty, interest, and complexity can be identified as components of aesthetic value. These factors play a role in determining the attention of learners and their perception of the relevance of a learning task which is a component of their motivation. The depicted objects may have emotional qualities of their own. Wounded victims of war or hungry people of Africa may evoke emotional responses that may have an impact for certain types of learning. Responses of anger, joy, curiousity, desire for justice, and other, may also be stimulated by appropriate use of drama. The filmic form of video offers excellent opportunities to exploit these possibilities. Recorded material has thereby the advantage of the carefully planned impact that results from skillful design and production.

Basic approaches for utilization

The above-mentioned video functions represent one set of variables to consider when designing practical application. Next to this, several basic utilization patterns may guide the designers:

Text primacy (symbolic first). Here, the basic question is: "Can printed material (text and pictures) do the job?" This starting point leads in many cases to cost-effective solutions. In cases where moving video is indispensible, this approach may be maintained by using barcode-controlled videodiscs as an adjunct to the written material. The approach is feasible for good readers with sufficient learning skills concerning the subject matter involved.

Visualization as starting point (iconic first). Here, the basic question is: "Can we show what we mean?" This starting point leads in many cases to a look-and-tell format on the basis of video presentations. It results in concrete presentations that may very well suit rather concrete subject matter (or it may enlighten abstract subject matter by visualization). It is feasible for group instruction as well as for individual study, may help poor readers, and may involve students that are not very motivated to read.

Between-channel redundancy as reinforcement strategy. Using two sensory channels increases the likelihood that messages arrive. This phenomenon may be used by developing educational materials in such a way that sight and sound are simultaneously used to present semantically overlapping information. The simplest (and most redundant) form is that a voice presents texts that can be read from paper or from a computer screen at the same time. Striving for semantically overlapping information leads often to audiovisual presentations in which schematizing is frequently used to support abstract subject matter with appropriate images. Between-channel redundancy as reinforcement strategy is appropriate for complex subject matter and/or poor learners as long as the total amount of information does not exceed the information processing capacities of the learners.

Orchestration for learning (theater of life). This concerns the use of the video function for emotional involvement. Creative communication solutions may attract and maintain attention, establishing learning situations that are entertaining, challenging, or have an emotional impact for other reasons. This technique is appropriate if motivation to learn is considered a problem, for instance in distant learning situations where the delivery of instruction takes place by means of television and has to compete with other television channels.

Audiovisual archive as a starting point (providing a computerized information environment). In this case the database capabilities of multimedia are exploited. This may be done for the purpose of knowledge acquisition in an eductional setting, where personal development is paramount. Free navigation through the information space is here the starting point albeit that the space available may be limited for didactical reasons to prevent novice learners from being overwhelmed by the difficulty level of encountered information or from getting lost in the possibly vast amount of information contained in the system. In all cases, adequate help functions should be available. For experienced users, playing around in the information environment offers ways to extent and deepen knowledge by enriching existing schemata with new facts or new combinations of facts.

An other application concerns problem solving on an individual basis with the multi-media system as the main source of information. In that case two more options are there: (a) the problem-solving activity is guided by the system (it is incorporated into a detailed planned teachin g method), or (b) the system is an open information environment in which the user has to find his or her own way. The level of support by the system may be adjusted to the needs of the user, either automatically (with an on-line help system that detects ineffective conduct of the user), or on request (when the user decides to switch from the browse mode to "challange me", "teach me", or "question me"). Applications may further take the form of interactive encyclopedia, interactive maintenance manuals, etc.

Interactivity as the starting point. This is the case when learning outcomes are desired for which it is considered to be necessary that practice, testing, and feedback are organized in interaction with the computer system. The main instruction functions are: orienting on the learning task (presenting subject matter, presenting content-specific ways of thinking, presenting new methods and techniques to operate on the subject matter, demonstrating working methods and problem-solving approaches), practice (providing opportunities to practice, providing feedback), testing and general feedback. For the organization of multimedia applications to serve these instruction functions, common computer-based instruction formats may be used, such as drill-and-practice, tutorial, and simulation, extended with the presentation richness of multimedia.

The video functions and the basic utilization patterns are not independent of each other. Figure 2 shows how the different functions relate.

Basic utilization patterns	Supported by the following video functions
Text primacy	- Limited supplementary use of content-related video
Visualization as starting point	- Content-related use of video - Depicting the invisible or the non-accessible - Logistic use of video - Cognitive help - Modelling of psychomotor skills - Providing observation materials - Video design for emotional involvement
Between-channel redundancy as reinforcement strategy	- All functions with proper audio layers added
Orchestration for learning	- Video design for emotional involvement
Audiovisual archive as a starting point	- Content-related use of video - Depicting the invisible or the non-accessible - Logistic use of video - Cognitive help - Modelling of psychomotor skills - Providing observation materials - Video to present gifted teachers
Interactivity as a starting point	- Modelling of psychomotor skills - Video feedback - Providing observation materials - Psychologically realistic simulations

Figure 2: Video functions from Figure 1 in relation to basic utilization patterns

The video functions and the basic utilization patterns form a limited set of factors to consider when selecting or developing multimedia applications. For instruction, proper handling of learning objectives, content analysis, and learner characterisitcs require thorough knowledge and skills with respect to the knowledge domain of the subject matter and of methods and theories of instruction, and knowledge and skills with respect to methods for multimedia design and production. These subjects are beyond the scope of the present paper. This contribution focusses on results from audiovisual research that relate to detailed design decisions for developing video presentations. This concerns primarily the utilization patterns "visualization as starting point", "between-channel redundancy as reinforcement strategy", and "orchestration for learning".
Much of the audiovisual research reported is carried out with linear video programmes. The findings are, however, probably to a large extent applicable to components for multimedia solutions.

Results of audiovisual research on presentation variables

Presentation variables are actually production variables that obtain their values during the production of video material. Below the following variables are discussed (derived from a list by Coldevin, 1981, p. 87):
(a)˘camera factors (angle & shot);
(b)˘setting;
(c)˘audio factors;˘
(d)˘special effects;
(e)˘pacing and rhythm.
In addition, a brief passage is devoted to animation. The variables are listed in Figure 3 in which they are positioned relative to the production phase in which the pertinent design decisions are taken.

Camera Factors
As far as research is concerned, the effects of camera factors on learning seem to be limited and results are often conflicting. Dwyer (1978, p. 168), for instance, refers to Roshal (1949) and McCoy (1955) to conclude that it is advisable to show a performance on the screen the way the learner would see it if he were doing the job himself. Coldevin (1981, p. 88), however, describes an experiment by Grant and Merrill (1963) that shows for relatively complex skills (and perhaps for most task-oriented productions) that the viewing angle of the demonstrator should not be used rather than the perspective of the student viewer who is watching the demonstration.

Research by Salomon (1974) seemed to show that certain camera factors -- such as zooming in -- can positively supplant visual information that young viewers must fill in during cuts between shots. It has, however, been shown that this supplanting effect can be demonstrated by other means (Bovy, 1983).

This effect is consistent with the fact that different authors often present different solutions to serve certain communication function by camera factors. Zooming-in for instance, is classified by Morrison (1979, p. 29) as a device for: focusing attention, relating parts to a whole, emphasizing one aspect, and showing spatial relationships. All these function can be accomplished by other means. Morrison himself says that the cut can be used to (re-)focus attention and to relate parts to the whole.

But there seems no reason to exclude the use of cuts for emphasizing and for showing spatial relationships. Moreover, for all these functions, the superimposition of optical markers can also be used (such as arrows, animation, encircling; see for instance Dwyer, 1978, p. 160). Lumsdaine and Sulzer (1951) had earlier shown the effectiveness of devices of this kind for directing perception in films. Boeckmann, Nessmann, an^I Petermandl (1988) confirmed this effect as part of an experiment in which subjects had to watch a video programme with the task to notice objects and procedures that are forbidden in a professional kitchen for hygienic reasons. In the experimental version of the programme, three things were made to stand out in a long shot by means of

Design decisions in production phase:	Presentation variable	Purpose	Examples
scripting and shooting	camera angle & shot	framing of to be depicted objects	close-up to focus attention, wide-angle shot to establish a visual context for a beginning scene, etc.
	audio (narration, live sound, and music)	supporting the visual layer or (in case of text) mainstream of factual information	narration to explain what the picture shows, live sound to demonstrate how a MIG-welding arc should sound, music to support a story-relevant mood.
scripting and editing (post production)	optical effects/special effects	getting attention, relating scenes, symbolizing transitions in place or time	wiping to connect mutually supportive or opposing visual situations, lap dissolve to move to a scene in the past, fade out/ fade in to suggest the passing of time, etc.
	pacing & rhythm	providing a presentation rate that gets and maintains thougthful attention (by complying with the spectators preferred state of cognitive pace)	shorting time by inserting only action-laden shots, edited for narrative continuity at an attention-demanding pace.
scripting, shooting, editing	animation	attention gaining and visualization	instructional visualizations without distracting details, focussing attention by animated pointing devices

Figure 3: Selected production variables for video materials

superimposed rings (flowers, cigarettes, and domestic animals). The results of that experiment show that: "the most impressive increase in recall was observed in the case of the point concerning flowers, these being difficult to see in the background of the picture (38% of the students who had seen the experimental version mentioned flowers in comparison with none of the students who had seen the original version)" (Boeckmann, Nessmann, & Petermandl, 1988, p. 118).

This supports the notion that camera factors do not have definite meanings that can be used as invariable building blocks in message design. Just like the ideas about editing that are put forward by Reisz and Millar (1981), the use of camera factors should be guided by the nature and order of the message components that are to be conveyed. Studying the effects of single shots seems not to be very useful in that respect. It is more that sequences of shots should establish adequate patterns to cover the scenes to be depicted. This is exactly what media handbooks offer to support the development of solutions for particular design problems. Arijon (1976) for instance presents hundreds of model solutions for a wide range of camera problems, varying from staging straightforward two-person dialogues to staging complicated mass scenes or finding solutions in confined areas such as the interior of an aeroplane. It seems thus warranted to approach the treatment of the camera from the perspective of staging a message as a coherent series of shots. Consistent authorship may thereby lead to a style that establishes clarity and appeals the audience. The following research results are consistent with this view:
Low angle shots can increase the perceived potency of a presenter, but the framing of these shots in the narrative structure has then to support this intention (Coldevin, 1981, p. 88).
In video programmes, interest levels can be increased with medium close-ups or with close-up shots (p. 88). Boeckmann, Nessmann, and Petermandl (1988, p. 110), however, concluded on the basis of their research that recall was not related to type of shot (close-ups, long shots, or intermediate shots).

These results illustrate that the function of shot type is dependent on the circumstances under which it is used. The camera treatment has thus to be regarded as a flexible component of audiovisual message design, whereby research-based rules to predict good results are weak or absent. Good results are dependent on the professionalism of responsible team members in a media project. Rules from practice such as can be found in media handbooks are useful to support design decisions (see, for instance, Arijon, 1976, or Millerson, 1985).

Audio factors
Audio factors are narration or dialogue (in the case of speaking characters), effects (the 'natural' sounds of the setting that is depicted on the screen (effects may be recorded live or be produced artificially), and music.
For instruction, off-screen commentary is often used. According to Dwyer (1978, p. 169), the number of words per minute of film in the commentary has a definite effect on learning. He refers to Zuckermann (1949a) and Jaspen (1950a, 1950b) to conclude that care should be taken not to "pack" the sound track. Schmidt (1974, p. 332) found in his analysis of the design of 20 outstanding instructional films that the majority of these films had an average narration rate of 140 or fewer words per minute. Dwyer (1978) advises that:

> "Too much or too little talking in words per minute of film has been found to detract from the teaching effectiveness of a film. The optimum word rate is about 100 words for each minute of film." (p. 172.)

The normal rate of speech ranges from 150 to 200 words per minute (Rossiter, 1971). This leads to a rule of thumb that it is a normal value for narration to take about two-thirds of the total presentation time of an instructional film.

Schmidt (1974, p. 332) also found that the majority of the outstanding instructional films he analysed: (a) did not use a style of narration that talked down or lectured to the audience; (b) did simplify the message as much as possible; and (c) used the active form of sentence structure. That 'simplification of the message' was a factor most probably related to the fact that the analysed films were not designed for specific audiences. Still, the message of Schmidt's observations is that narration should take the audience seriously, present in a clear, concise, and unambigious way, and talk directly to the audience if the subject allows it.

About the other factors -- effects and music -- research results are very limited. Fleming and Levie derived one principle with respect to concept learning; that if a concept is basically temporal -- such as rhythm or time or sequence or frequency, or like poetry or music or speech -- then audition is appropriate (Fleming & Levie, 1978, p. 48). Research about sound effects was not mentioned further by the authors reviewed. The informational and emotional nature of this kind of sound seems to be considered as self-evident. Research about music in instructional audiovisual programmes is scarce. When Coldevin (1981) prepared his review, he could refer to only one study (by Baggaley, Ferguson & Brooks, 1980). In that study different types of music for opening or closing a programme were subject to experimentation with unconclusive results due to methodological problems (Coldevin, 1981, p. 89). With respect to music, Jaspers (1991a) reinforced the conclusions made by Zuckermann (1949b) that music has informational, emotional, and conceptual/integrative functions. Leit-motivs and other musical effects may help to structure a presentation and inform the listeners about what is going to happen. Tempo, modality, and rhythm may be used to evoke emotional responses. According to Jaspers, proper use of music may support instructional messages but -- unless the topic is about music -- there is no need to use it "when the purpose is transmission of referential information and cognitive information processing" (Jaspers, 1991a, p. 50). Music may, however, facilitate learning by giving students occasions for identifications and empathy. However, as Jaspers puts it: "well-chosen music does not guarantee to create the supposed effect, but it is highly probable that ill-chosen music will do much harm to the learning process" (Jaspers, 1991a, p. 50).

Given the limited results from research, the main conclusion has to be that the treatment of sound effects and music has to lean on rules from practice. Inspiring ideas can, for instance, be found in Millerson (1985, p. 353-362).

Optical effects/special effects

The review by Dwyer (1978) as well as more recent research by Boeckmann, Nessmann, and Petermandl (1988) show that optical effects such as fades, wipes, and dissolves do not increase the instructional effectivity of films or video programmes compared to straight cuts to connect subsequent shots. Ginsburg, Bartels, Kleingunther, and Droege (1988) found that with special effects, the situation may even be worse. They carried out experiments with a programme that contained highly abstract visual effects and found that these effects diminish recall. Most probably, the observation of Boeckmann, Nessmann, and Petermandl (1988) applies that formal elements -- such as a fades or wipes -- that do not relate to the programme content have no influence on recall (which according to Ginsburg et. al. may even be negative in the case of special effects). Boeckmann et. al. demonstrated that formal elements that played an explicit role to define a message proved to influence recall. The conclusion seems to be that deliberate content-related use of

optical effects or special effects can be feasible, depending on their functionality that affects the quality of a message. As with the use of the other presentation variables, the message design has to be content driven. This is, however, not to deny that form influences content. The eventual meaning of a message is determined by the combination of the depicted and the manner of depiction. It may be stressed that for instructional purposes, form and content should be balanced with the intention to reinforce the substance of the instructional message.

Pacing & rhythm

A question is, in what way does the pace of presentation in films or video programmes have to be controlled to account for cognitive pace (the rate of mental processing of incoming data)? One principle is that: "the rate of development of a film should be slow enough to permit learners to grasp the material as it is shown (Jaspen, 1950a; Ash & Jaspen, 1953)" (Dwyer, 1978, p. 168).

According to Dwyer this means that the rate must be slow rather than fast. The outstanding instructional films that were analysed by Schmidt (1974):

> "... had a rate of development that was slow enough for the viewer to grasp the material as it was shown" (p. 332). "... had a slowing of the rate of development at points at which it is necessary for the viewer to change attention from one source of information to another" (p. 332). "... had an average shot length of about 10 seconds" (p. 334).

The 10 seconds are of the order of magnitude of the time that Simon (1974) has put forward as the time it takes to fix a chunk of information in long-term memory. The same 10 seconds seem also to be candidate for a characteristic parameter in a study by Leahy (1983). Leahy studied the relationship between visual realism and information processing time in viewing projected visuals. His results, with respect to manipulating projection time to promote more efficient visual comprehension, did not yield clear advice. He got, however, the impression that the fact that he did find significant differences between projection times of 5 and 10 seconds and between 5 and 15 seconds, but not between 10 and 15 seconds, that after 10 seconds a ceiling affect might have occurred. Whether this means in general that a mean cutting rate of six shots per minute yields an adequate pace of an instructional film can, however, not be concluded.

Coldevin (1981) referred to a study by Schlater (1970) that showed that cutting rate should not be too slow:

> "Schlater (1970) produced five videotapes in which the visual changed ranged from one every 30 seconds in the first treatment to nine per 30-second interval in treatment five. Three types of learning tests were administered: pictorial video (visual sketches), verbal video (verbal descriptions of pictorial information) and audio channel information. Testing results showed that verbal video comprehension increased directly with the increase in the rate of visual changes (levelling off at seven visuals per 30-second interval), but the opposite effect was noted in pictorial video recall. As might be expected, no significant differences were found between the treatments on recall of audio channel information." (Coldevin, 1981, p. 91)

It thus seems that under most circumstances a cutting rate that corresponds with a mean shot length of about 4.5 seconds may be feasable.

A further study by Vincent, Ash, and Greenhill (1949) studied the relationship of length and fact frequency to effectiveness of instructional films. "Fact frequency" may thereby be conceived as a factor that is directly related to the cognitive pace mentioned earlier. The procedure in the study was as follows:

"Four experimental film versions dealing with the causes and manifestations of the weather were made up from a series of Navy training films on aerology. The Long Heavy version ran 29 minutes and contained 224 facts; the Long Light version also ran 29 minutes but contained 112 facts. The Short Heavy version ran 14 minutes and contained 112 facts; the Short Light version ran 14 minutes but contained 56 facts. The total number of words in each pair of equal length kept constant by the use of repetitions, prefatory statements, and other 'filler' material which did not add new facts. The four experimental versions were shown to four groups in each of three different populations, High School students (12th grade), Air Force basic trainees, and College students. In each population a fifth control group did not see the film. All groups took the same 136 item multiple-choice test. The High School and Air Force groups took the test again after delays of four weeks and seven weeks respectively." (Vincent, et al., 1949, p. 1.)

The pace in the heavy versions was thus about one retainable fact per 7.5 seconds. In the light versions about one retainable fact per 15 seconds was presented. The reported narration rate was about 124 syllables per minute. The results showed that significant learning occured:

"Every group that saw experimental film earned a substantially higher score than the control group which did not see a film. ... For the High School sample the Short Heavy version seemed to be most effective, for the Air Force and College samples the Long Light version seemed to be most effective. At the end of the delayed recall period all differences among the versions were much smaller than they had been on the immediate retention test, and most of them were not significant." (Vincent, et al., 1949, p. 1)

Test scores on immediate recall ranged from slightly more than 40% to about 50%, in the experimental groups; delayed test scores were roughly speaking 20% lower. Differences between groups were of the order of magnitude of 0 to 5%. Vincent, et al. point at the fact that the films were rather difficult for the populations used. Their overall conclusion is that:

"It seems clear from the data that packing more and more information into a film yields only very slight increments in total measured learning (underlining omitted, pwv). In no case did the Long Heavy film group learn anything approaching twice as much as the Short Heavy or Long Light groups, nor did the latter learn twice as much as the Short Light group." (Vincent, et al., 1949, p. 2)

With respect to the audio channel, the narration rate that was discussed under "audio factors" also plays a role in pacing a programme. The narration may "drive" the processing of visuals more when the two information channels are sufficiently correspondent (Grimes, 1990, see also the passage about two channels below). Clear research-based rules on how to proceed when deciding on cutting rate and narration-related pacing, however, do not exist.

Animation

Animation is traditionally a representation technique from the film and video world. It varies from simple stop-motion formats in which message components are stepwise developed (in instructional situations usually synchronous to narration) to detailed cartoons in full motion. The technical developments of computers have led to beginning possibilities to integrate animation into computer-based instruction.

Rieber (1990) posits that in computer-based instruction animation has been used to fulfill or assist one of three functions: attention-gaining, presentation, and practice. Rieber sees reason to advise that animation should be incorporated only when its attributes are congruent to the learning task. These attributes are: visualization, motion, and trajectory (= the path of travel of an animated object).

In the audiovisual world, the situation is not much better as far as research is concerned. The usefulness of animation techniques seems, however, to be accepted as rather self-evident. Animation is considered to be a common presentation option that can be put into operation whenever its application seems feasable. The functions mentioned by Rieber are then also at stake, as are even simpler applications such as providing cueing devices like superimposed boxes and arrows.

An important feature of animation is that animated visualizations can be strictly to the point, without any distracting detail. Wember (1976), for instance, did an experiment with a video report about the political and societal conflicts in Northern Ireland. In this report one sequence was about the historical causes of these conflicts. The images that accompanied this sequence were originally scenes of a town (street scenes, graffity on walls, etc.). Wember replaced these images by an animated scheme of the historical development (on the basis of a highly stylized map of the British isles) that proceeded synchronous to the narration. In this way he was able to demonstrate a dramatic gain in recall and comprehension scores with respect to the intended message (from an initial score of 30% correct with the original version to a score of 80% correct with the version in which the live scenes were replaced by the animation). Wember suggested that the effect of the animation was especially convincing because of the fact that the supported message was abstract. It is generally difficult to find realistic images that support abstract messages that are contained in the commentary. Animated schematic drawings may in that case offer the solution and add to the impact of the presentation.

Aspects of information load

Next to presentation variables, the communicative features of video presentations depend on the cognitive load they cause in the mind of the viewers. Picture complexity should not be beyond what a learner is able to understand and the audio and video channel should not be thus information loaded that they compete for the attention of their audience. In this section, relevant research is reviewed leading to a list of considerations that designers should keep in mind when working on video segments (Figure 4).

Picture complexity
"Picture complexity" refers to the syntactic, semantic and pragmatic difficulty of comprehending a picture. Other factors also can determine complexity:

- Density of information in the sense of both the number of picture elements or objects and of the degree of detail with which each element is depicted (Peeck, 1987, p. 137).
- Syntactic cues such as overlap of objects to augment the depiction of depth.
- Semantic clarity, which refers to the ease with which picture elements can be called by name.
- Pragmatic clarity, which concerns the kind and amount of existing knowledge that is needed to interpret the picture.

Each of these factors have been subject to research with respect to a diversity of variables that can be identified to play a role. Overviews can be found by Goldsmith (1984, 1987), Peeck (1987) and Leahy (1983). Here, only some general issues are discussed with respect to the use of realistic video images as well as the use of schematic representations.

The effectiveness of realistic pictures for learning has been a matter of debate for a long time:

> "An ongoing controversy exists in the literature regarding the role of realism in visualized instructional materials. A number of theorists, writing during the 1940s and early 1950s, suggested the existence of a realism continuum along which all materials could be scaled in relation to their instructional effectiveness. ...
> However, more recent researchers ... have disagreed with these theories on the grounds that more realistic materials will tend to present too many irrelevant cues which will interfere with learning. Miller (1957) suggests that too many irrelevant cues may actually compete with one another for attention and subsequent information storage. ... for some educational objectives, simplified or less realistic visual instructional materials are more effective in falicitating student achievement than more complex photographic or detailed drawings of the same object. Dwyer found strong evidence to indicate that the most realistic visual illustrations were not necessarily the most effective instructionally." (Parkhurst, 1975, p. 175-176)

Heuvelman (1989, p. 38-40) discussed the results of several studies that suggest that for instruction, schematic visualizations yield better learning results and are thus preferred. Dwyer (1972) provided arguments why realistic images may hinder learning in the case of externally paced presentations (as in video programmes):

> "The initial impact of the excessive realistic detail may be sufficiently strong to detract attention from relevant and important learning cues. ... The process of indentification and discrimination is time consuming; the more intricate the visual stimuli, the longer it takes for the student to identify and absorb the intended information." (Dwyer, 1972, p. 90-91.)

The research of Dwyer and others focused on the dimension of realism-schematism. This focus may, however, distract from the real instructional issue. The question is whether the instructional goals need the presentation of concrete referents (to teach concrete concepts, to demonstrate psychomotor procedures, to embed instruction in a familiar context; or any other application for which it is necessary to provide real-world schemata that require "gestalts" with proper fidelity) or whether schematic visualizations are better to articulate the instructionally relevant features (visualizing structures, relations, and principles).

In the case that real-world schemata are indicated, results other than those in favour of schematic visuals may be found. Indeed, Leahy, in his research with fixed-pace presentation of visuals, found that complex high-realism visuals promoted a significant increase in visual comprehension over low-realism visuals Leahy used colored visuals of high complexity on two levels of realism that were of relevant instructional content to social studies, with emphasis on object-interrelationships and conceptual content, rather than mere object depiction. Subjects were public high school sophomores. The properties of the high-realism visuals that seem to be responsible for his results may, according to Leahy, be "a more meaningful, coherent, or experientially recognizable pattern of object-interrelationships" in these pictures (Leahy, 1983, p. 107).
With respect to picture complexity, Leahy (1983, p. 111) listed as one of the implications of his study that high-realism visuals are apparently more efficient with respect to the recall and comprehension of presence and appearance of information and of the interrelationship of objects.
Next to this, another argument for some degree of complexity is that complexity invokes interest, as is apparent from one of the research-based principles of Fleming and Levie: "attention is drawn and held by complexity, providing the complexity does not exceed the perceivers' cognitive capacities" (Fleming & Levie, 1978, p. 22).

A last point is that picture quality has to be such that the images can be appreciated without technical imperfections. Fleming and Levie formulated one of their principles for instructional message design: "the better an object or event is perceived, ... , the more feasible and reliable will be further cognitive processes, e.g., memory, concept formation, problem solving, creativity; and attitude change" (Fleming & Levie, 1978, p. 88).
The use of professional video formats and professional camera treatment and editing facilities seem thus to be indicated in order to produce effective video materials.

Using two channels
In audiovisual presentations, the visual channel and the audio channel are used simultaneously to convey messages. Several researchers have tried to find how these two channels interact. Jaspers (1991b) reviewed research regarding the relationship between sound and image. His findings, supplemented with findings of Dwyer (1978) and Kozma (1991), are that:
"Visual images are reflections of physical presence" (Arnheim, 1986), presenting "concreteness" (Mast, 1977) that is represented by the surface of the depicted objects and events. Sounds are, in most cases, attributes of visual objects (Metz, 1975), with the exception of sound objects such as a hiss, thunder, music (Jaspers, 1991b, p. 164). But, according to Metz, voices may also be aural objects as far as they have meaning of their own, apart from the words spoken (recognizing an off-screen voice may be important to value the meaning of its speech). For instructional applications this is, however, a minor point in most cases or even not relevant.
Language communicates thoughts (Arnheim, 1986); it presents abstractions (Mast, 1977). This counts whether or not language is presented visually (in print or on a video screen) or as an audible sound.
When used in combination, most researchers conclude that an audio-visual combination can be more effective than audio alone or video alone (Hoban & Van Ormer, 1950, reprinted in 1970; Coldevin, 1981; Nugent, 1982). Kozma (1991, p. 191) reviewed more than ten studies in which separate audio and visual presentations of a video programme were compared and found that: "in none of these studies did the combination of audio and visual information result in lower recall than recall from either source alone. In most of these studies, the combined use of visual and auditory symbol systems resulted in more recall than visual-only and audio-only presentations." Although it is thus often the case, it not always evident, that audio plus vision is better (Hsia, 1968). The effects of the combination appears to be relative to factors of learner and material (Hoban & Van Ormer, 1950; Johnston, 1987; Barton, & Dwyer, 1987).
Often, dominance of vision over audio is reported. "The overall influence of the motion picture is thought to be primarily in the picture and secondarily in the accompanying language" (Dwyer, 1978, p. 172). Visually presented information would be retained better than aural information. But, for instance, Hsia (1968) concluded that "the question of supremacy of the auditory or visual channel is controversal. Some studies indicate that seeing is better than hearing, others show the reverse" (Jaspers, 1991b, p. 164-165).
These results seem to support one of the principles for improving visual learning that was proposed by Dwyer:

> "Both audio and visual elements of films are effective channels of communication. Neither channel is consistently better than the other. Each channel is uniquely capable of conveying certain types of information and the two should be properly integrated." (Dwyer, 1978, p. 172.)

The results also agree with one of the research-based principles of Fleming and Levie:

> "More learning can occur where information is received concurrently in two modalities, e.g., vision and audition or vision and touch, than where received in only one modality." (Fleming & Levie, 1978, p. 107)

In instructional audiovisual programmes, sounds other than language or music are in most cases attributes of visual objects in the sense of Metz' (1975) assertion. (Instructionally relevant sound objects other than music do, however, exist. Examples are ticks that increase in speed to inform learners about the approach of the end of a period for a timed answer, and the different warning signals and other tones that are often used to give feedback on learner actions during learner-computer interaction. For audiovisual presentations, sound applications of these types are not very often used.)

With sounds as attributes of visual images, the relationship between the visual images and language becomes the central issue for instructional audio-visual message design, in particular if the language consists mainly of off-screen narration, which is the case with the often used look-and-tell format. It has, however, to be noted that Boeckmann et. al. (1988, p. 110) found that in their experiments no influence on recall could be established in connection with the fact "whether the main source of sound was shown or not (e.g. whether the commentator was visible or a voice-over was used)". This suggests that conclusions with respect to off-screen narration may apply to presentations by a studio presenter as well.

With respect to off-screen narration two variables are at stake: (a) the correspondence of the visually presented information and the commentary; and (b) the use of narration-supporting superimposed text on screen. Both are treated below.

Correspondance of video images and audio narration

The relationship between the information in the two channels determines whether the proper integration occurs as Dwyer has suggested. Some researchers have put forward the idea that "redundancy" and in particular "between-channel redundancy" plays a role. Jaspers (1991b, p. 168) describes that redundancy is formally defined as one minus the ratio of actual-to-maximum information transmission, but that the common use of the term is much more informal and refers to superfluous, extra, or repetitive information. Hsia (1971; 1977) has opted for optimal between-channel redundancy which he sees as the key to better communication. Between-channel redundancy in audiovisual communication occurs if information that is presented in in the visual channel matches the information that is at the same time presented in the audio channel. A methodological problem appears to be that it is not an easy matter to decide on the extent to which certain information can be conceived to be redundant. Pictures have, for instance, many cues that may be used by learners to connect new information to elements of their existing cognitive structure, while with audible text it is assumed that to be redundant to the picture only one perspective with respect to that picture is offered. This concerns the problem of the limited possibilities of translating information that is represented in one communication mode (for instance text) into a representation in another mode (for instance a visualization). In the past decades, a body of research and theory has developed with respect to sign systems (often also referred as symbol systems, where the term "symbol" is then used as a synonym of "sign"). Gross (1974, p. 60) speaks of primary modes of symbolic behaviour and distinguishes: (a) the linguistic, in which oral or written language is carrying the messages; (b) the social-gestural, in which facial expressions and body

language communicate messages between people; (c) the iconic, in which communication takes the form of visualizations; (d) the logico-mathematical, in which the symbolic language of mathematics constitutes an independent way of communication; and (e) the musical, in which people express themselves with musical sounds. They are: "identified with (a) a range of objects and events or field of reference, (b) a distinctive memory-storage capacity, (c) a set of operations and transformations, and (d) specific principles of ordering which govern the formulation and communication of meaning, and (e) nontranslatability into other modes" (Gross, 1974, p. 61). With the last point, Gross means that information which is coded within one mode will not be capable of being fully recoded in terms of another. Nontranslatibility is thus a characteristic of a communication mode which indeed limits the possibilities for between-channel redundancy. It is therefore better to speak of more or less correspondence between pictures and sound, whereby strong correspondence resembles redundancy but is, in fact, not the same. This is here thought to be one of the reasons why results of experimental research fail to demonstrate that striving for redundancy yields results that contradict predictions on the basis of cue-summation theory (see for instance Severin, 1967). Cue-summation theory says that adding non-redundant cues in different channels enriches a message, thus offering more opportunities for learning (as long as the information processing system of the learner will not be overloaded), and redundant cues do not (because they add no new information). If after all alleged redundant information appears not to be as redundant as was assumed, improvement of learning that is reported on the basis of redundancy may very well be the consequence of cue-summation. A second reason why redundant cues may support learning despite of the predictions of cue-summation theory is, that in this theory the didactically beneficial effects of repetition are not taken into account. In practice, most probably, both reasons play a combined role.

Grimes (1990) used a study of Drew and Grimes (1987) as starting point to study the influence of channel correspondence on recall of auditory or visually presented information.

> "Drew and Grimes found that in the optimum viewing condition -- high channel correspondence -- audio recall and story understanding were the highest, and video recall was the lowest. In the least optimum viewing condition -- no channel correspondence -- video recall was the highest, audio recall was the lowest, and story understanding was the worst." (Grimes, 1990, p. 16)

It has to be noted that Grimes' research concerned television news, a format in which the main stream of information is traditionnally contained in the audio channel. Grimes reasoned that the results of Drew and Grimes are a consequence of limited memory and/or attentional capacities:

> "Channel correspondence probably affects the way in which attention is divided between the auditory and visual channels. Because attention is a limited commodity (Kahneman, 1973), more attentional capacity is probably required to encode and integrate in memory the two information channels when those two channels convey slightly to moderately different messages. With enough difference in messages (e.g., a medium-correspondence condition), attention's capacity threshold will probably be approached, maybe even exceeded, and viewers may try to concentrate on the auditory channel -- the who, what, when, where, why channel -- at the expense of the less specific, and less useful, visual channel. ... ...high channel correspondence should allow the viewer to monitor the auditory channel for the who, what, when, and where of the story and to shadow the visual channel for information that supplements the narration and can be integrated into the information supplied by it. Thus, attention to, and memory for, the visual channel should be greater in this condition than in the medium-correspondence condition.

However, if the conflict between the two information channels is great enough (e.g., the no-correspondence condition), attention to the visual channel will override attention to the auditory channel." (Grimes, 1990, p. 16)

This last idea is, according to Grimes, not only supported by the non-correspondence data from the Drew and Grimes study, but also by the work of Colavita (1974) and Posner, Nissen, and Klein (1976) who report that visual stimuli dominate auditory stimuli when pictures and words have no relationship to one another (Grimes, 1990, p. 17). Grimes carried out an experiment in which he focussed on the locus of attention as it was split between the auditory and the visual information channels. "The purpose was to discover which channel, if either, received less attention due to diminishing channel correspondence" (p.17). He used three versions of four television news stories as stimuli. Grimes operationalized "High Correspondence" by a "tight" picture-word match in the experimental material. When, for instance, the narration talked about a needle with the size of a screwdriver that is inserted into a herniated disk in the spine, the picture showed a needle, the size and shape of a screwdriver, about to be inserted into the spine of a patient. "Medium Correspondence" was operationalized by relating the two information channels thematically but with no further correspondence. The narrated sentence mentioned above (about the needle) was then accompanied by a video scene of a patient being wheeled into surgery.

In the "Non-Correspondence" condition, the visual track consisted of a visual potpourri that did not match the audio. "For instance, as the narrator described how herniated disks are repaired, the viewer saw a barge loaded with garbage anchored in New York Harbor. When the shot changed, it showed celebrants of the most recent Chinese New Year, while the narration continued to discuss surgery" (p. 18). Story narrations were the same across all conditions. Attention to the visual or the auditory channel was measured with a reaction-time technique based on visual or tone probes. Half of the subjects were exposed to seven visual probes (NTSC colour bars during 33 milliseconds) nested within each story, and the other half were exposed to analogous tone probes (with a frequency of 10 kiloHertz). In the technique, subjects have to react to the visual or auditory signal each time that it appears by pushing a key as soon as possible. The reaction time is a measure of attention. The longer it takes, the more attention is assumed to be devoted to the channel within which the signal appears (due to the channel capacity that is occupied by the attention). Two recognition posttests were used: (a) a factual memory test with 53 multiple-choice questions; and (b) a 36-item visual memory test on the basis of freeze frames from video material that was used in the stories as well as from "outtakes" (shots not included in the stimulus material). Subjects were 202 undergraduate communication majors who worked individually through the experiment.

The results showed no statistically significant differences between factual memory scores in the high- and medium-correspondence conditions (the scores were 56% and 54% respectively). In the no-correspondence condition, factual scores were much lower (35%), but the auditory probe reaction times were not significantly different from these times in the other conditions. "This Suggests that subjects were paying attention to the auditory channel, but that they did not remember much of the factual information contained within" (p. 23). Grimes discusses that this is consistent with the earlier mentioned observations of Colavita (1974) and Posner, et al. (1976) and also of Cohen (1973) who described that visual signals appear to go through fewer extrapolations than auditory signals before they result in memory codes. "Visual messages do not need as much attention to be efficiently encoded, and therefore get priority entry, ..., into the human information-processing system" (Grimes, 1990, p. 23). If unrelated auditory and visual stimuli are competing for

simultaneous processing, visual encoding primacy then keeps the factual information from being properly processed.
Visual recognition scores for the high-, medium-, and non-correspondence conditions were 66%, 55% and 64% respectively. The high visual recognition scores for the non-correspondence condition can partly be explained on the basis of the visual encoding primacy, that also caused the low factual memory scores in case of extreme audio-video conflict. In this condition, reaction times to the visual probes were relatively short, suggesting that the visuals were processed only to the point of recognition. The difference between visual recognition scores for the high-, and medium-correspondence conditions is statistically significant. It shows that audio-video correspondence influences the total amount of information that can be processed mentally per unit of time. In the high-correspondence condition longer reaction times to tone probes were positively correlated to visual recognition scores ($r = .387$, $r2 = .150$, $p < .025$):

> "This suggests that as subjects paid more attention to the narration, they were able to process the video better, and so they produced better visual recognition scores. In other words, as subjects paid more attention to what was said, they used their remaining attentional capacity to integrate what they saw with what they heard. This result suggests that when the two information channels are correspondent, the narration 'drives' the processing of the visuals." (Grimes, 1990, p. 24.)

This is seemingly in contradiction to the view of Kozma (1991, p. 192), who tends to conclude that comprehension of video appears to be driven by the processing of visual information:

> "This is apparent from a study by Baggett (1984), who varied the temporal order of audio and visual information within a video presentation on the names and functions of pieces of an assembly kit. In this study, the narration was presented in synchrony or 7, 14, and 21 seconds ahead of or behind the visual presentation. College students performed best on immediate and 7-day delayed tests of recall of the synchronous and 7-second, visual-then-audio presentations. The worst performance was by groups with the audio presented first. This suggests that, in a video presentation, the visual symbol system serves as the primary source of information and that the audio symbol system is used to elaborate it."

The two studies combined, however, need not yield a conflicting perspective. It may very well be that learners take the first few moments after switching to a new shot to process the new visual image to a level of recognition that is sufficient to be open to subsequent elaboration which is then guided by narration. In that case, Kozma's conclusion that comprehension of video appears to be driven by the processing of visual information, has at least partly to be rejected.

The question of excessive information load due to lack of audio-video correspondence appeared also in a study by Wember (1976). Wember analysed the informational structure of filmed background reports about the difficult political situation in Northern Ireland. He found that the filmmakers edited the visual layer of these films in such a way that they are dynamically paced and have an attractive rhythm. This had, for instance, the consequence that static shots were held relatively short (mean projection time: 2 seconds), while at the other end of the scale shots with movement of the camera and movement in front of the camera at the same time ran uninterrupted relatively long (mean projection time: 5.9 seconds). The content of the films did, however, often not motive this editing style. Despite the fact that the filmmakers denied this, it seems that their professional consent that "film is movement" played them tricks.
This is an occasion to stipulate that the media profession is differentiated. Media professionals who are schooled to work in the entertainment industry have, for instance, a

quite different view of their field than media professionals who are educated to serve educational communication. The need for differentiated schooling is, however, still recognized by scanty measure. The cooperation between filmschools or schools of cummunication and departments of educational technology is still very limited. This is the more problematic, now that multimedia technologies open a market where the combined skills of both worlds are inevitably needed.

Wember perceived that the main effect of the dynamic pacing is that it attracts attention and prevents viewers from switching to another channel when these films are broadcast on television. But he was also able to demonstrate that the superfluous "Augenkitzel" (tickling the eyes), as he called it, demanded so much from the visual processing capacity of the viewers, that the intended, mostly rather abstract messages in the audio channel were not understood or at least not stored into memory although the viewers reported that they thought that they did. He concluded that the gap between pictures and commentary in the films he analysed in many cases forced the viewers to divide their attention between competing channels, with a consequence that they failed to really take in anything substantial of the presented information. Wember's study confirms that lack of correspondence between the visual channel and the audio channel is detrimental for learning. Unlike the findings of Grimes, in Wember's case the recall of the pictures dropped to a very low level.

Wember's results pertain to attention processes in the visual channel that hindered the appreciation of the information in the audio channel. Another mechanism also exists. Boeckmann et al. (1988) assert that picture continuity takes precedence over a change of subject in the commentary:

> "When there is a change of subject in the commentary, even if this should amount to no more than taking up a new aspect of the same subject (such a change as is indicated in a written text by a new paragraph) and there is no corresponding structural marker (e.g. a cut, a graphic, flashing) the continuity of the information carried by the picture conceals the jump from one idea to the next and leads to reduced recall of the point in the commentary. Take, for example, the commentary that moved from 'the optional school subject' to 'the compulsory subject', while throughout moving pictures of a school class were shown. The analysis of the poor recall revealed that the experimental subjects had largely failed to perceive the transition."
> (Boeckmann et al., 1988, p. 112)

Heuvelman (1989) carried out several experiments with respect to between-channel correspondence and also came to the conclusion that "the relationship between the audio track and the visuals is of paramount importance to information processing by viewers" (p. 167). One of the factors he studied concerned the effects of studio presentation on camera in comparison to realistic or schematic visualizations of abstract subject matter. His results led him to conclude that:

> "With abstract subject matter it is very difficult to match pictures with sound when using realistic visualizations. In that case, studio presentation on camera will lead to better results. ... With an increasing level of abstraction of the text, realistic pictures can only show a limited number of aspects or elements of what a certain idea or concept fully means. At the same time, in the eyes of the beholder, realistic pictures can have many potentional meanings. Selection of the intended meaning, i.e. that intended by the maker of the programme, is not imperative. ... In schematic visualizations, a selection, or abstraction, from reality has already taken place: only elements of interest are represented. In that case picture and sound will show a better match and, consequently, processing and subsequent retention of the information will be better."
> (Heuvelman, 1989, p. 167.)

The view of Heuvelman implies that lack of between-channel correspondence does not only result in less learning if the information processing capacity of the learners is overloaded, but also if it leaves room for learners to invest their mental effort to derive non-intended meaning. That the use of schematization may help to solve this problem was also demonstrated by Wember (1976), when he used animation instead of live images to support abstract content that was presented through the audio channel.
In all, enough support exists to believe that proper between-channel correspondence promotes learning and that the amount of between-channel correspondence affects the information load of audiovisual presentations. How to control between-channel correspondence is, however, a complex matter. Factors involved are: (a) the concreteness or "visualizationess" of subject matter; (b) the matter of enrichment versus overload; (c) avoidance of distracting information; (d) amount of cueing of auditory content elements by optical markers or changes of shots; and (e) the mutual tuning of audio and pictures in general, inclusive of the wording and timing of commentary relative to the pictures. For every new product, the designers have to make content-driven local decisions to optimize between-channel correspondence with respect to these factors. It goes beyond the scope of this review, to elaborate design procedures to cope with these factors. A few general elements are incorporated in Figure 4 that serves as a conlusion of this section.

Superimposed text
A particular form of between-channel correspondence is formed by superimposed texts that support narration. Heuvelman (1989) reviewed studies of Coldevin (1975), Nasser and McEwen (1976) and Nugent (1982) that show that the presentation of verbal information through two channels (visual and audio) yields information gain compared to audio only, but that no difference was found relative to the presentation of verbal information through the visual channel only (text on screen). This latter form is, however, rather artificial when the use of television is concerned. Heuvelman (1989) himself carried out a few experiments to find out whether short superimposed texts that support narration help recall of presented information. His earlier mentioned conclusion that with abstract subject matter, studio presentation on camera will lead to better results than the use of realistic visualizations was extended with the conclusion that "adding redundant superimposed titles can also lead to better results, but is of less importance and should be applied with care, taking into account the information density of the 'background' picture" (p. 167).

Van der Heijden (1987) carried out an experiment with three conditions: (a) audio supported by short texts on screen against a neutral (blue) background; (b) audio plus live-action images; (c) audio plus live-action images and supporting captions. In this last condition only main points were supported by individual words or short statements near the bottom of the screen. The audio track was the same in all conditions. The programme took about ten minutes to present and contained information about a certain social service. This subject was rather abstract, the reason why the images in the last two conditions were, in many cases, not a 100% substitute for the screen texts from the first condition (which supported the narrated text in a way that resembles the use of the overhead projecter to present information point by point). Subjects were 61 students from the last year of a lower technical school and 62 students from the last year of a lower level high school. Conditions were about equally distributed over school types and learners. A pretest-treatment-posttest design was used. All tests were multiple choice. The results showed that the second condition (audio plus live-action images) did worse

than the other two conditions (audio plus text only and audio with live-action images plus text). The reason for this might have been that the imperfect match of the images with the narration appeared a burden to the information processing abilities of the subjects, yielding a less effective use of the two channels than in the case where text on screen was available.

The work of Heuvelman and of Van der Heijden give reason to expect that superimposed texts that support narration may be beneficial for learning.

Conlusions with respect to information load
Research is not very conclusive with respect to picture complexity. A differentiated view emerges in which complexity seems desirable to invoke interest, indicated if a need for concrete (real-life) referents exist, and to be avoided if the presentation of structures, relations, and principles is the central focus of the intended communication. These conclusions are summarized in Figure 4.
The effects of using two channels and superimposed text appear to be dependent of the communicative intention which controls the kind of visuals used, and the relative importance of (oral) text. A few general conclusions are summarized in Figure 4.

Summary

The video components of multimedia applications may serve many different functions, such as providing content-motivated moving images, supporting mental imagery by visualizations, and stimulating personal (emotional) involvement with objects of study. The role of video will further be determined by the way in which video is positioned in relation to the non-video components of the system. In that respect, video may be chosen as the primary form of presentation around which all the other components are organized. But the use of video components may also be limited to support text-based materials where the use of video seems inevitable. Or as just one of the resources that users may encounter when browsing through a multimedia database. In all these cases, the video components should be designed with suffcient clarity to fulfill their roles in the communication process. In this contribution, research was reviewed with respect to production variables that should be properly controlled to accomplish video segments of sufficient impact. In sum, the results are as follows:

Camera factors
Research with respect to camera factors illustrates that the function of shot type is dependent on the circumstances under which it is used. The camera treatment has thus to be regarded as a flexible component.
Research-based rules with respect to camera factors are very limited. A firm rule from practice is that for instruction the camera treatment should be content driven. Each camera angle ought to be motivated by its function in the presentation.

Source of information load	Positive indications	Negative indications
Complexity through pictorial realism	May promote recall and comprehension (Leahy, 1983); invokes interest (Fleming & Levie, 1978)	To many cues may interfere with learning (Parkhurst 1975)
Reduced complexity through schematization	Simplified material is more effective for student achievement (Parkhurst, 1975); schematic visualizations yield better learning results (Dwyer, 1972)	Simplified visualizations may lack meaningfulness (Leahy, 1983)
Combined use of the visual and the audio channel	The combination can be more effective than the use of only one of the two channels (for instance: Kozma, 1991), specifically if the capabilities of both channels are properly integrated (Dwyer, 1978); when the two information channel are correspondent, narration 'drives' the processing of visuals (Grimes, 1990)	The combination can lead to excessive information load, which is detrimental for learning (for instance: Wember, 1976)
Attention-demandig visuals, while the audio signal carries the main message	Viewers are capable of concentrating on the audio channel and are able to learn from it, if monitoring the visuals does not cause cognitive overload (Grimes, 1990)	Visuals get priority over audio messages during perceptual processing. In cases of too many information, the audio information may not arrive properly in memory (Grimes, 1990)
Reduced load of two-channel messages by schematization	Schematizing abstract subject matter supports understanding and learning of narration-driven presentations (Wember, 1976; Heuvelman, 1989)	
Lack of visual cues to mark transistions from one subject to another		Visual continuation of a scene may mask substantial changes in the narration leading to less effective learning (Boeckmann et al., 1988)
Focussing effect of superimposed text	Superimposed text may support learning (Heuvelman, 1989; Van der Heijden, 1987)	The use of superimposed text is of less importance than the prevention of distracting realistic visual images (Heuvelman, 1989)

Figure 4. Information load of video materials

Narration

Video commentary should take the audience seriously, be presented in a clear, concise, and unambigious way, and talk directly to the audience if the subject allows it.

Sound effects and music

Findings from research with respect to the use of sound effects and music is very scarce. Here too, the main conclusion has to be that the treatment of these variables has to lean on rules from practice.

Optical effects and special effects

Findings from research with respect to the use of optical effects or special effects seems to show that deliberate content-related use of these effects may augment the quality of a message.

Pacing

Clear research-based rules about how to proceed when deciding on cutting rate and narration-related pacing appear not to exist. As with the other audiovisual design variables, in this case the design decisions are also subjected to professional judgement in each specific case.

Technical qualities

Picture quality has to be such that the images can be appreciated without technical imperfections. These requirement can be met by using professional video formats and professional camera treatment and editing facilities to produce video materials.

Correspondance of video images and audio narration

Enough support exists to believe that proper between-channel correspondence promotes learning and that the amount of between-channel correspondence affects the information load of audiovisual presentations. How to control between-channel correspondence is, however, a complex matter. Factors involved are: (a) the concreteness or "visualizationess" of subject matter; (b) the matter of enrichment versus overload; (c) avoidance of distracting information; (d) amount of cueing of auditory content elements by optical markers or changes of shots; and (e) the mutual tuning of audio and pictures in general, inclusive of the wording and timing of commentary relative to the pictures. In all cases, mental overload should be avoided. If the amount of information becomes more than the learner can handle, visual primacy seems to inhibit learning from the audio channel.

Superimposed text

There is reason to expect that superimposed texts that support narration is beneficial for learning.

Despite the research findings and due to the limited direct applicability of these findings, a conclusion is that the judgement of an experienced producer and other experienced media personnel is indispensible in meeting professional standards. This puts media professionals in an important position because of the fact that media design directs the impact of instructional messages. The control over media variables is essential to optimize instructional communication. This factor counts for economic advantages of media, for the motivational effects of media and for media-specific didactics that extend the options for organizing instructional strategies in the sense of Reigeluth (1983, p. 18). It is hoped that the research reported here as well as subsequent research on (interactive) message design will lead to more systemized knowledge to support design processes.

References

Arijon, D. (1976). Grammar of the film language. London: Focal Press.

Arnheim, R. (1986). The images of pictures and words. Word & Image, 2, 306-310.

Ash, P., & Jaspen, N. (1953). The effects and interactions of rate of development, repetition, participation and room illumination on learning from a rear-projected film. Technical Report, SDC-269-7-39, Port Washington, NY: Special Devices Center, Office of Naval Research.

Baggaley, J., Ferguson, M., & Brooks, P. (1980). Psychology of the TV image. Farnborough: Saxon House.

Baggett, P. (1984). Role of temporal overlap of visual and auditory material in forming dual media associations. Journal of Educational Psychology, 76, 408-417.

Barton, E.A., & Dwyer, F.M. (1987). The effect of audio redundancy on students' ability to profit from printed-verbal/visualized instruction. International Journal of Instructional Media, 14, 93-98.

Boeckmann, K., Nessmann, K., & Petermandl, M. (1988). Effects of formal features in educational video programmes on recall. Journal of Educational Television, 14, (2), 107-122.

Bovy, R.A. (1983, April). Defining the psychologically active features of instructional treatments designed to facilitate cue attendance. Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

Cohen, G. (1973). How are pictures registered in memory? Quarterly Journal of Experimental Psychology, 25, 557-564.

Cohen, P., Ebeling, B., & Kulik, J. (1981). A meta-analysis of outcome studies of visual based instructi on. Educational Communication and Technology Journal, 29 (1), 26-36.

Colavita, F.B. (1974). Human sensory dominance. Perception & Psychophysics, 16, 409-412.

Coldevin, G.O. (1975). The differential effects of voice-over, superimposition and combined review treatments as production strategies for ETV programming. In J. Baggaley, G.H. Jamieson & H. Marchant (Eds.), Aspects of Educational Technology VIII (pp. 55-65). Bath: Pitman Publ.

Coldevin, G.O. (1981). Experimental research in television message design: Implications for ETV. Programmed Learning and Educational Technology, 18, 87-99.

Drew, D.G., & Grimes, T. (1987). Audio-visual redundancy and TV news recall. Communication Research, 14 (4), 452-461.

Dwyer, F.M. (1972). A guide for improving visualized instruction. University Park, PA: State College, Pennsylvania State University, Learning Services Division.

Dwyer, F.M. (1978). Strategies for improving visual learning. University Park, PA: State College, Pennsylvania State University, Learning Services Division.

Fleming, M., & Levie, W.H. (1978). Instructional message design: Principles from the behavioral sciences. Englewood Cliffs, NJ: Educational Technology Publications.

Ginsburg, H.J., Bartels, D., Kleingunther, R., & Droege, L. (1988). Cosmos revisited: Just how effective are special effects for instructional communication? International Journal of Instructional Media, 15 (4), 319-326.

Goldsmith, E. (1984). Research into illustration: An approach and a review. Cambridge, England: Cambridge University Press.

Goldsmith, E. (1987). The analysis of illustration in theory and practice. In H.A. Houghton & D.M. Willows (Eds.), The Psychology of Illustation: Instructional Issues (pp. 53-85). New York: Springer-Verlag.

Grant, T.S., & Merrill, I.R. (1963). Camera placement for recognition of complex behaviours. Television in Health Sciences Education, Chapter 6. Washington, DC: US Office of Education.

Grimes, T. (1990). Audio-video correspondence and its role in attention and memory. Educational Technology, Research & Development, 38 (3), 15-25.

Gross, L. (1974). Modes of communication and the acquisition of symbolic competence. In D.R. Olson (Ed.), Media and symbols, the forms of expression, communication, and education. The Seventy-Third Yearbook of the National Society for the Study of Education (pp. 56-80). Chicago, IL: University of Chicago Press.

Heuvelman, A. (1989). Buiten beeld. (Off screen.) Lisse: Swets & Zeitlinger.

Hoban, F, & Van Ormer, E.B. (1950). Instructional film research, 1918-1950. Fort Washington, NY: U.S. Naval Special Devices Center.

Hoban, F, & Van Ormer, E.B. (1970). Instructional film research, 1918-1950. New York: Arno Press & The New York Times.

Hsia, H.J. (1968). On channel effectiveness. AV Communication Review, 16, 245-267.

Hsia, H.J. (1971). The information processing capacity of modality and channel performance. AV Communication Review, 19 (1), 51-75.

Hsia, H.J. (1977). Redundancy: Is it the lost key to better communication?. AV Communication Review, 25 (1), 63-85.

Jaspen, N. (1950a). Effects on training of experimental film variables, Study I: verbalization, rate of development, nomenclature, errors, "how-it-works", repetition. Technical Report, SDC-269-7-17, Port Washington, NY: Special Devices Center, Office of Naval Research.

Jaspen, N. (1950b). Effects on training of experimental film variables, Study II: verbalization, "how-it-works", nomenclature, audience participation, and succinct treatment. Technical Report, SDC-269-7-11, Port Washington, NY: Special Devices Center, Office of Naval Research.

Jaspers, F. (1991a). Music in audio-visual materials. Journal of Educational Television, 17 (1), 45-52.

Jaspers, F. (1991b). The relationship sound-image. International Journal of Instructional Media, 18 (2), 161-174.

Johnston, J. (1987). Electronic learning: From audiotape to videodisc. Hillsdale, NJ: Lawrence Erlbaum Associates.

Kahneman, D. (1973). Attention and effort. New York: Holt, Rinehart & Winston.

Kozma, R.B. (1991). Learning with media. Review of Educational Research, 61 (2), 179-211.

Leahy, M.D. (1983). The relationship among field dependence/field independence, visual realism, and information processing time in viewing projected visuals. Unpublished doctoral dissertation, University of Connecticut.

Lumsdaine, A.A., & Sulzer, R. (1951). The influence of simple animation techniques on the value of a training film. Washington, DC: US Air Force Human Factors Research Lab.

Mast, G. (1977). Film/cinema/movie, a theory of experience. New York: Harper & Row.

McCoy, E.P. (1955). An application of research findings to training film production. Technical Report, SDC-269-7-44, Port Washington, NY: Special Devices Center, Office of Naval Research.

Metz, C. (1975). Aural objects. In E. Weiss & J. Belton (Eds.), Film Sound, Theory and Practice (pp. 154-162). New York: Columbia University Press.
Miller, N.E. (Ed.) (1957). Graphic communication and the crisis in education. AV Communication Review, 5 (3), 1-120.
Millerson, G. (1985). The technique of television production. London: Focal Press
Morrison, G.R. (1979, April). The design of instructional television programs. Paper presented at the Annual Meeting of the American Educational Research Association. San Francisco.
Nasser, D.L., & McEwen, W.J. (1976). The impact of alternative media channels: Recall and involvement with messages. AV Communication Review, 24 (3), 263-272.
Nugent, G.C. (1982). Pictures, audio, and print: Symbolic representation and effect on learning. Educational Communications and Technology Journal, 30 (3), 163-174.
Nugent, G.C., Tipton, Th.J., & Brooks, D.W. (1980). Use of introductory organizers in television instruction. Journal of Educational Psychology, 72 (4), 445-451.
Parkhurst, P.E. (1975). Generating meaningful hypotheses with aptitude-treatment interactions. AV Communication Review, 23 (2), 171-183.
Peeck, J. (1987). The role of illustrations in processing and remembering illustrated text. In D.M. Willows & H.A. Houghton (Eds.), The Psychology of Illustation: Basic Research (pp. 115-151). New York: Springer-Verlag.
Posner, M.I., Nissen, M.J., & Klein, R.M. (1976). Visual dominance: An information processing account of its origins and significance. Psychological Review, 83 (2), 157-171.
Reigeluth, C.M. (1983). Instruction design: What is it and why is it? In C.M. Reigeluth (Ed.), Instructional-design theories and models: An overview of their current status (pp. 3-36). Hillsdale, NJ: Lawrence Erlbaum Associates.
Reisz, K., & Millar, G. (1981). The technique of film editing. London: Focal Press.
Rieber, L.P. (1990). Animation in computer-based instruction. Educational Technology, Research & Development, 38 (1), 77-86.
Roshal, S.M. (1949). Effects of learner representation in film-mediated perceptual motor learning. Technical Report, SDC-269-7-5, Port Washington, NY: Special Devices Center, Office of Naval Research.
Rossiter, C.M., Jr. (1971). Rate-of-presentation effects on recall of facts and of ideas and on generation of inferences. AV Communication Review, 19, 313-324.
Salomon, G. (1974). Internalization of filmic schematic operation in interaction with learners' aptitudes. Journal of Educational Psychology, 66, 499-511.
Schlater, R. (1970). Effect of speed of presentation on recall of television messages. Journal of Broadcasting, 14, 207-214.
Schmidt, W.D. (1974). Analyzing the design of outstanding instructional films. International Journal of Instructional Media, 1 (4), 327-336.
Severin, W. (1967). Another look at cue summation. AV Communication Review, 15 (3), 233-245.
Van der Heijden, M.P. (1987). Tekst en videobeeld. Een onderzoek naar de vormgeving van het videobeeld door teksten en/of live-action videobeelden in informatieve video-voorlichtingsprogramma's [Text images and video images. An experiment into the realization of the video image by texts or by live-action images in informative video programmes]. Enschede: University of Twente, Faculty of Educational Science and Technology, Department of Instrumentation Technology.

Verhagen, P.W. (1993, April). Multi-Media: Basic Approaches for Utilization. Contribution to the COMETT training programme EuroMedia Training: Entwicklung von Fernstudienmodellen im bereich Medizin und Gesundheitswesen für Anwender und Multiplikatoren, Magdeburg, 27-28 April, 1993: Otto von Zernike Universität.

Verhagen, P.W. (1992). Length of segments in interactive video programmes. Unpublished doctoral dissertation. Enschede: Faculty of Educational Science and Technology, University of Twente.

Vincent, W.S., Ash, P., & Greenhill, L.P. (1949). Relationship of length and fact frequency to effectiveness of instructional motion pictures. Technical Report, SDC-269-7-7, Port Washington, NY: Special Devices Center, Office of Naval Research.

Wember, B. (1976). Wie informiert das Fernsehen? (How does television inform?) Munich: List Verlag.

Zuckermann, J.V. (1949a). Commentary variations: Level of verbalization, personal reference, and phase relations in instructional films on perceptual-motor tasks. Technical Report, SDC-269-7-4, Port Washington, NY: Special Devices Center, Office of Naval Research.

Zuckermann, J.V. (1949b). Music in motion pictures: Review of literature with implications for instructional films. Technical Report, SDC-269-7-2, Port Washington, NY: Special Devices Center, Office of Naval Research.

Design and development of multi media applications

Designing Multimedia Applications

Maud van den Meiracker

Abstract

The design and development process of multi media applications has to follow a structured approach. After a needs analysis, an educational design has to be developed. On the basis of this a functional design will describe the software architecture, which will be implemented in the next phase. In multi media applications content design is most important. Therefore high level editors are necessary. Also new expertise is needed in multi media design. One needs graphical designers and audio-video producers who are able to cooperate with educational technologists.

Designing Multimedia Applications

Introduction

Computer based training applications have moved from character-based interfaces towards graphical user interfaces and from using only one data type, namely text, towards the integration of different data types, such as text, graphics, audio and recently also stills and (full motion) video.

This shift from character-based towards multimedia applications has had implications for the design process. These implications will be discussed in this paper.

The Design Process

Over the years Andersen Consulting - ECC has developed its own educational software engineering methodology. This methodology contains a number of distinct phases. In each of the phases specific expertise is used to facilitate the process and to guarantee the quality of the final product.

The main design phases are:

- Needs analysis
- Educational Design
- Functional Design
- Technical Implementation
- Implementation and evaluation

The main responsibility during the first two phases lies with the educational technologist. A computer scientist develops the functional and technical design and monitors the programmer. Implementation specialists, often people with an education degree, are responsible for the introduction and use of the developed computer application.

For each of the 5 phases the implications for the use of multimedia will be discussed.

Needs Analysis

The main questions which need to be addressed during this phase is which needs validate the use of a multimedia application. In order to answer this question, a short overview of types of multimedia based applications will be presented.

Multimedia applications
The following categories can use multimedia effectively:
- corporate training
- sales and marketing
- entertainment
- education/training
- business desktop uses
- integrated performance support

Corporate training
These applications are especially used for the training of new employees or the retraining of existing employees when new products or procedures are introduced. Multimedia is used for different purposes such as:
- 'personal' introduction of the CEO and or other key-persons of the organization
- visualization of the company, plant, etc.
- use of simulations of the 'real' work which needs to be carried out
- enhance motivation (training may be first introduction with new company)

Sales and marketing
The objective of sales and marketing multimedia products is to promote, sell and provide customer service for specific products and services.
Examples are electronic brochures at a travel agent to select a holiday destination; at banks to choose between different kind of saving options; touch screen information booths at the Olympic games and other events, etc.
Multimedia is being used to make an attractive presentation to the user who is used to the glitz and creative polish of the TV and movie commercials.

Entertainment
The expectation is that multimedia entertainment will grow rapidly with the introduction of the CD-I players, which are connected to a television. The home-market is the primary target group for multimedia entertainment applications. Applications consist mainly of interactive games. Multimedia is used to make the games more attractive by providing graphics, animations (cartoons), stills and video and of course sound-effects. The entertainment multimedia applications can be seen as an extension to the popular computer games like Nintendo and SEGA.

Education/training
It is expected that the market for multimedia education and training will quickly expand. With the prices of multimedia computers falling and the hardware becoming more powerful, multimedia will (partly) replace existing CBT and add many new applications which are highly attractive and effective. The educational goal of multimedia application is to impart knowledge in the most effective way. This can be realized for example in classes where students have

access to information from different cultures, languages, music, etc. Multimedia may provide more realistic and complete information and when integrated with well-designed computer-based training may enhance the learning process.
Multimedia applications can be used very effectively in training situations where simulations are required. American Airlines, for example, uses interactive multimedia to cut down on the use of expensive full-scale flight simulators.

Business desktop uses
Multimedia usage for business desktop applications is not wide-spread but will certainly grow in the near future. The most promising applications are video mail and teleconferencing.

Integrated Performance Support (IPS)
Integrated performance support is mentioned separately because Andersen Consulting has a special interest in this area. The use of multimedia within integrated performance support often will be a subset of combination from the above mentioned categories. The goal of IPS is to support the knowledge worker. This can be realized with different IPS 'services' including CBT, advisory, on-line help, computer-based referencing and work flow. Multimedia can be very effective in the CBT, advisory and computer-based referencing services.

During the needs analysis phase a good 'match' should be established between the specific needs for a computer application and the best solution. Of course, this is not new. Only now the option for multimedia is quite realistic, the educational designer needs to be familiar with the added value of multimedia and needs to know when the possibility of multimedia should be further investigated. Also the educational technologist should have some idea about the costs for developing a multimedia application.
Even if multimedia seems to be the best fit for the specific needs, this does not necessarily mean that multimedia will be selected. Often budgetary constraints for both the development as well as the purchase of the delivery platform may lead to a different choice.

For the remaining part of this paper, we assume that the choice for a multimedia application has been made and we will discuss the implications for the different design phases following the needs analysis phase.

'Educational' Design

The 'educational' design is an important phase in the design process. Educational is placed between quotes since not all categories suitable for multimedia mentioned in the previous chapter, fall in the category education.
This immediately points to one of the new skills for the educational designer within AC-ECC which has surfaced with the introduction of multimedia development. The focus is not only on an educational context but also on entertainment, point of sales which may include marketing aspects, integrated performance support, etc. Where training and learning were the most important goals for CBT applications, the different multimedia applications have different goals. The well-known and proven instructional strategies for CBT are not always applicable to other multimedia applications.

The educational design is of course closely linked to the outcomes of the needs analysis. The high level goals and objectives for the application to be developed have been defined in the needs analysis phase. During the educational design phase these goals and objectives will be translated into:

- the overall structure of the application
- the high-level navigation
- level of user-control
- instructional strategies and transactions or in case it does not concern a CBT-program the presentation modes
- content specification

Assuming that the decision has been made to develop a multimedia application, the following issues, specifically linked to multimedia, need to be addressed in this phase:

Structure
Where, when and how will the different data types be used in the application?
Decisions will more often be based on availability of existing material (e.g. video and photographs); budget and time lines than on real design issues such as what is the most effective way to present information.

High level navigation and user control
How will the user access information and find his way throughout the application?
Decisions have to be made with respect to the menu structure; use of hypertext; free browsing; free or fixed entry points, etc. This is especially important when using linear presentations such as video and audio. The user will need to stop video and audio at any point, backtrack at any point in time and sometimes the user should be able to skip certain presentations.

Instructional strategies/ transactions
The availability of more data types does not necessarily result in a high quality application. On the contrary, more can go wrong when using different data types. The correct choice for a certain data type in relation to the (instructional) goal is not always simple and to be honest we do not even know for certain the best match.
If, for example, the goal is to introduce a new employee to the board of directors, just presenting a list of names may be less effective than presenting a list of pictures. However, it is still unclear if a short video presentation of each of the directors will be more effective than showing the photographs with some additional textual explanation. This will very much depend on the quality of the video as well as on the target population.

Content specification
The design should include specifications of all the content being used. Since more data types are being used, this means additional specifications in comparison with character-based applications where a description of font, letter size and style might have been sufficient.
The actual scripting will take place in the next phase(s), but in this phase should be specified which data types will be used for which purpose. Furthermore, a description should be provided such as 'short video fragment showing the outside and the inside of World Headquarters'.

Functional Design

The choice for using multimedia in an application has also implications for the functional design in which the overall architecture of the application as well as the detailed functionality will be specified.
Andersen Consulting - ECC has successfully used the building block approach, of which the separation of (CBT) code and data, the development of both a (CBT) runtime program as well an authoring facility and the re-use of software building blocks are the main characteristics. Using this approach has resulted in very different design documents compared to the often used story-boards in multimedia design. The story-boards most often are linearly organized, describing one screen after the other. The AC-ECC approach results in a description of drivers, containing the way data is presented to the user on the screen with all the interactivity involved. The data are stored in a database which has to be designed by the computer scientist. In order for non-programmers to fill the database, an authoring program will be developed. This means that the functional design contains a description of the authoring facilities as well.

No clear protocols have been developed within AC-ECC for describing the use of video, stills, sound and graphics within the functional design document. This is often done in a separate document, called detailed design or scripting document.

Detailed design
The detailed 'content' design describes in detail the different data types which are being used. This includes the following aspects for each of the different data types:

Text:
- font(s)
- letter size(s)
- style
- size of paragraphs (often linked to the size of the 'text-boxes')
- use of horizontal and/or vertical scroll bars
- color

Graphics:
- description of pictures needed
- size of graphics (often linked to the size of the 'graphics-boxes')
- format (PCX, BMP, etc.)
- metafile
- color
  - depends on screen (monochrome; VGS; super-VGA)
  - use of specific palette
  - use of corporate colors
- co-ordinates (where to place on screen)
- transparancy

Audio:
- quality (11 or 22 MHz; 8 or 16 bits)
- voice (male; female; child)
- length of audio-fragments
- with/without background music
- specific effects
- specific intonation

Stills:
- quality
- size (often linked to the size of 'stills-box')
- description of stills needed

Video
- description of video needed
- quality (PLV or less)
- length of video fragments (closely linked to costs and storage space)
- size (full-screen or less)
- combination with music or voice-over

User Interface Design

Another important part of the functional design is the user interface design. User interface design is important for all computer applications. However, because of the differences in multimedia applications as mentioned in the first chapter, it should be clear that some applications will be used by inexperienced and also infrequent users (such as point of sales and point of information). This requires special attention with respect to the user interface.

The use of different data types may also result in rather chaotic and inconsistent applications. We often see that the philosophy 'the more, the better' has been applied, which of course is hardly ever true. We recommend a rather 'dull' background using very quiet colors (like light grey) and predefined screen areas for video and still presentation and text and/or graphic presentation. The use of photographs, video and graphics will most likely bring enough color to the application. Therefor, we recommend to use only a couple of colors which have a certain meaning (for example red to indicate an answer is incorrect, green to indicate an answer is correct).

Using different input mechanisms next to the mouse and the keyboard should definitely be considered. Touch screens, track balls and joy sticks may be much more user friendly for certain applications, especially if relatively little input is required.

Overall, prototyping is a nice way to gradually design the definite user interface. This may cause some problems because of lack of in-house facilities and multimedia content material. But even without specific content, the user interface may be tested. A big advantage of AC-ECC's software engineering approach is that it is rather simple to change the user interface. Because of the separation of code and data, and the driver principle, changes in the user interface do not have to be realized all over the application, which is often the case when using authoring programs.

Technical Implementation

The technical design and programming phase for a multimedia application does not differ very much from designing character-based applications with the exception if different technologies and dedicated tools are being used, such as in the development of CD-I.
AC-ECC uses Visual Basic 3.0 in combination with DVI-technology to develop multimedia applications. Also, when video is not a very important aspect of the application Video for Windows can be used, with the advantage that no special hardware needs to be purchased.

Because of the basic building block approach, parts of the technical design and sometimes even code is being re-used in new projects. This is of course very efficient.

Because of the large amount of data often used in multimedia applications, special attention needs to be paid to a DBMS. AC-ECC has used several applications such as DB-Vista, Access and Visual Basic's database engine.

A totally new activity in this phase of the design process, specifically related to multimedia, is the data production. The multimedia data need to be produced and be placed in the database before the authoring process, actually linking all the data together within the program shell, can start

Multimedia data production
Professional production of multimedia data requires a multidisciplinary team. Each of the different data types requires different expertise. All these qualities will very seldom be combined within one person.

Text production
Depending on the type of application, different demands will be placed on the text quality. A good point of sales, for example, requires text writers with a marketing background. A training application requires a clear description of the subject matter and well-stated questions and feedback. Subject matter experts as well as educational technologists should work together to accomplish a quality product.

Graphics production
To make a multimedia computer application compatible with everything we see daily on TV and in magazines, it is imperative to involve a computer graphics expert for the graphics production. It is important to realize that a graphical artist who is used to paper design, is not necessarily suited to develop computer graphics. Best results are obtained when the graphical expert draws straight on the screen since drawing on paper and afterwards scanning of the image, often reduces the quality.
The graphical designer should be creative and should also be able to listen well to the subject matter expert and to translate ideas into graphics, with all the restrictions the computer screen imposes.
The graphics will have to be produced in the correct format (PCX, BMP or something else, depending on the technology used.) Also special attention should be paid to the filenames being used. Since all graphics will be stored in the database, it is helpful to think about meaningful names in order to facilitate the filling of the program shell later on during the authoring process. Actually, this applies to all data types used.

97

Audio production

Next to preparing the text which will have to be spoken it is also important to select the right voice. Professional 'voices' can be selected from a number of voice-bureaus in the Netherlands. Depending on a global description of your wishes, you can listen to audio fragments of different voices and select the appropriate voice for the multimedia application.

Once the voice is selected and the text is completed, it is important to mark the text for specific intonation, pauses, etc. Very often the spoken text is used in combination with the presentation of stills and/or graphics. Timing will be done afterwards in most cases, but specific pauses should be taken into consideration when recording the text.

In order to guarantee good quality, the recording should be done in a sound proof studio with good recording equipment. The text should be sent to the narrator beforehand for practice and should be recorded without any errors.

Especially when multiple languages are being used, it is important to compare the lengths of the texts in the different languages. Rewriting may be necessary to match the lengths as well as possible.

When the recording is finished, the anolog audiofiles will have to be converted to digital audiofiles. Here, it is important to choose the quality level. Highest quality will be obtained using 22 MHz and 16 bits. This of course will produce larger files than when 11 MHz and 8 bits files are used.

Digitizing can be easily done by using special tools such as Splice.

Video production

Special experts are needed to guarantee quality video in your application. You do not only need a good camera, sound and light technician, but also a good scenario expert and possibly a professional script writer. Producing video for a computer application requires different skills than producing video for a TV-show or movie. Oftentimes the video-clips in computer applications are rather short. This is because 1 minute video takes up 10 MB of disk-memory and longer video-fragments may reduce interest in the user.

Decisions will have to be made with respect to using existing material or shooting new material. For new production it may be necessary to select actors, a studio, stage material, background music, narrator, etc.

Just as with audio, video needs to be digitized as well. To obtain PLV quality, the video needs to be sent to special studios (e.g. Paris) where digitizing can be done on special high speed and volume computers for a considerable amount of money ($500 for 1 minute of video).

Multimedia Authoring

Another part of this design phase is the authoring process. As mentioned before, AC-ECC uses a software engineering approach where the code and the data are completely separated. This means that when the program shell has been coded by the programmer and the data have been produced and stored in the multimedia database, all the links will have to be put together in the authoring process.

The authoring facilities are built by the programmer and are easy to use. Establishing all the links when using the authoring facilities does not require any programming skills.

The author is often the educational technologist, but it can also be a subject matter expert.

Testing
Like with any software product, testing is an important part of the technical implementation phase. The difficulty with testing multimedia applications is the need for the delivery platform, which often is a 486 computer with DVI board and very large hard-disk. Sometimes, no additional computer is available next to the development computer.
Because of the size of the application, you cannot just send a couple of diskettes to the subject matter expert or client to have the program tested. Installation of the application often requires an external hard-disk or a tape-streamer. Compatibility may be a problem, so it is important to have clear procedures.
Because of the separation of the code and the data, it is advised to develop a testing protocol addressing the two parts separately. Graphics, audio and especially video will already have been tested before being digitized. This reduces the chances of having to make major changes to these parts of the data.

Implementation and evaluation

Developing a multimedia application does not guarantee proper and effective use by the target audience. It is important to support the implementation process and also to evaluate the use of the application.

Just as with testing, the delivery platform for multimedia is somewhat more complex than with regular computer applications. The multimedia applications need to be properly installed. This is possible by using an external hard-disk, a CD-ROM or a tape-streamer. This almost always requires assistance from a technical assistant.

Manuals are poorly read and not very much used. Furthermore, manuals are not suitable for point of sales and/or point of information applications and entertainment, since users should be able to access the application without any additional instruction (of course some instruction may be placed on the screen, such as: Select your language choice).
For multimedia training applications and simulations, where learning goals are important, guidance and possibly a help desk should be considered. In the next two decades we may still expect many inexperienced computer users in the target audience of the multimedia applications to be developed.

Evaluation of multimedia applications (and regular applications) often does not get very much attention. This is a pity, since much is to be learned from observing computer users and from discussing their experiences. Too often designers assume ways users will react and response, without ever having tested or validated this assumed behavior. Evaluation results are also strong selling points for the initial high investments which have to be made when starting a multimedia production.

99

Conclusion

The design of multimedia computer applications has a number of consequences which do not apply for regular software engineering.

- Content plays a much more important role than in traditional applications. This means that during the educational design phase decisions need to be made with respect to the added value of using the different data types in relation to the specific (business/ educational) needs. The (educational) designer will have to be familiar with the different possibilities and the added value of multimedia.

- The interactivity of multimedia is not very well known. We should be careful that multimedia programs do not become video or slide-shows.

- Multimedia development definitely requires multi-disciplinary teams. This poses an additional burden on the project management of a multimedia production. Managing the creative processes of graphical designers, script writers and video producers should not be underestimated.
  Timelines will be under much more pressure, since there is much more interdependency in multidisciplinary teams.

- Data production will seldomly be done in-house, because expensive equipment and studio facilities are required. This creates additional dependencies.

- 'Standardized' protocols will enhance the communication between team-members.

- In order to develop maintainable applications, it is important to keep the program code and content data separate. This is realized within AC-ECC by using a regular software engineering methodology for multimedia productions. Many of-the-shelf multimedia authoring tools do not support this separation of code and data, which reduces the flexibility very much.

- Cost estimates of multimedia applications are still not very easy to make. Much depends on the preparation of the data and the desired quality of the data.

- With the prices of hardware reducing, multimedia applications will take a growing market share, which will only stimulate the demand for more multimedia applications since critical customers will not accept anything less attractive.

Multimedia development tools

Jan Schoenmaker, Erik Nienhuis

Abstract

When specifying multi media tools one starts with defining the optimum between the needed efficiency of development and the flexibility for an author. Given the importance of content design in multi media applications, high level structure and content editing tools should be available with which an author can design and develop applications in an easy and cheap way. As an example a dedicated authoring environment for multi media development is being described.

Criteria for tools selection

Efficiency and flexibility of tools

The discussion on the functionality of tools for developing multimedia applications is partly the same as in the case of regular software development. Does one need high flexibility than a regular programming environment will certainly support the development. However the efficiency of the development process may be quite low. In order to increase this efficiency one builds environments in which a number of facilities support faster development. Where does this increase in efficiency come from? This is due to the definition and implementation on beforehand of certain functionalities which may be useful in an application. The developer has only to put in some parameters and part of the application will be generated automatically. In regular automation we then talk about fourth generation environments, in training about authoring systems. However, one has paid a price in using such a tool: because part of the functionality is pre-defined, one has less flexibility. One can say that it is dependent on the type of application and context factors like maintenance but also expertise which is necessary which will decide upon the selection of tools.

Expertise as a third criteria for selecting tools

As said, expertise of the developer is a major variable in using a tool. Although regular programming environments are very handy, programming is a highly specialised activity.
This is a major issue in application domains like training, where one primarily needs expertise in instructional design, human computer interaction and learning psychology.
Computer based training therefore not only demands for software engineering knowledge and skills but also content design skills.
Here comes the issue with multimedia. In the past content design was restricted to writing dialogues and using simple graphics. Now, with multimedia the demand is for 'scripting' content in which as well the cognitive, interaction oriented activities with computer based training as the more affective, contextual activities of film are being combined. So, a designer has to be as well an instructional designer with a strong focus on cognitive aspects as a film maker with a focus on contextual and affective aspects.
So content design in multimedia computer based training has become more complex.

101

Developing a new type of tool with new technology

One can distinguish three criteria when selecting or defining authoring tools: efficiency, flexibility, expertise. One can put the well known tools like authoring systems, authoring languages and programming languages in relative position. Authoring systems have a restricted functionality and flexibility, but high efficiency or power of development. With programming environments it is the other way around.

Given nowadays technology one can take a new perspective however. Available are now generic tools like user interface management and data base tools. Making using of this technology has brought the opportunity to develop a new kind of authoring tools, leading to as well high efficiency and flexibility in specifying all kinds of functions.

With this technology an application can be seen as consisting of three distinct parts: the user interface part, the functional part and the database part. Certain environments combine a user interface management system and regular programming features, like for instance Visual Basic.

Others combine this also with a database part, like it is in hypermedia systems. However, the storage of data in a hypermedia system is based on the card concept. A card represents the userinterface part with a fixed link to a content part. Linking cards to each other means fixed links, leading to maintenance problems if one wants to change links. Using regular database technology , implies that maintenance can be done in an efficient way. Therefore, in general we prefer the use of regular database technology to organize the different datatypes in multi media.

Focus on content design

What does the availability of these new tools mean?

These hypermedia systems and programming environments are in itself already high level tools. They have on board a user interface management system and also support a number of relevant functions in developing computer based training: user interface and storage of (multimedia)contents. They lack functionalities typical for authoring systems like pattern matching for processing of answers or registration facilities. But given the high level of sophistication of these programming environments one can built these relatively easy. Therefore we come to the statement, that making use of regular software engineering architectures and tools, one can built environments which are competitive with authoring systems in terms of efficiency. These environments will be built on the basis of specific client needs. So the flexibility issue is resolved on beforehand.

Maybe that the most important characteristic is that one builds these tools in such a way that authors just have to use structure and content editors. Because the functionality of the dedicated authoring tool is defined on beforehand, the author can concentrate on course structure and course content. As stated before this is highly critical in multimedia design because of its complex relations between text, graphics, audio and video.

In the next chapter an overview will be given of the design considerations of this method and of a specific authoring environment developed by Andersen Consulting - ECC. Because it is based on defining and implementing basic building blocks which can be combined as bricks in building a house, this method is called the basic building block approach.

The basic building block approach.

The ECC building block approach has four main aspects:

- separation of CBT code and data;
- development of two programs in a project: a CBT runtime program and an authoring facility;
- organizing software into instructional units;
- customizing reusable software building blocks for the specific needs of a project.

It has to be noted that each of these aspects is an integral part of *"the"* ECC building block approach. The approach is not just about instructional units, nor just about re-usable code. It is about all four aspects combined together.

Below, each of these aspects is further explained:

Separation of CBT code and data
Separation of code and data is a fundamental principle of software engineering. It means that the functions or logic of a program are separated from the data on which these functions operate. However, for developing CBT, this has not always been common practice.

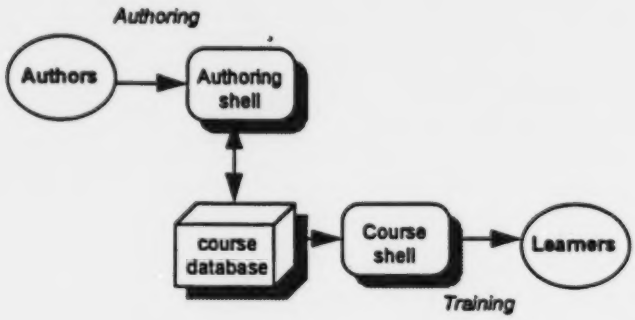
In the ECC building block approach, the CBT logic is rigorously separated from the course-specific CBT data. With course-specific CBT data, we do not only mean the course *content*, but also the course *definition*. The course contents are the texts, graphics, audio, stills or video that contains the information to be learned by the learner. The course definition specifies how this information is organized in the course, e.g. in terms of modules, the exercises contained in a module, the sequence of presentations, etc.. In a way, the course content is the training material, the course definition is the training structure.

The CBT logic is the way in which this data is presented to the learners on the screen, with all the interactivity involved. In the ECC building block approach, this logic is programmed in the form of so-called *drivers*. A driver is a piece of code that takes a (corresponding) set of CBT data as input, in order to deliver this data on the screen according to the programmed logic. For example, a multiple choice driver takes data like the question-text (string), the answer texts (n strings), and the number of the right answer (integer) as input to deliver this multiple choice question on the screen.

It is obvious that, once a driver is programmed, it is very cost-efficient to make a lot of CBT with it, for only the data has to be specified. In a way, the CBT data (including the course definition) acts as an extensive set of parameters for the CBT code. One can now 'author' CBT by simply parametrizing it. This approach is very different from CBT development with conventional 'authoring environments' (such as Syllabus or Authorware), where the code (interactivity, logic, branching) is completely interwoven with the course definition and contents, and where, consequently, authors and instructional designers are programming the CBT and editing the course at the same time.

103

Two applications: CBT and Author
Based on the separation of code and data, the CBT will be delivered through a CBT program with the CBT logic, containing all the drivers, and a CBT database with the course data (contents and definitions). However, in order for authors to fill and edit the database, a second program is needed: an authoring program. In the ECC building block approach, the CBT program is usually called *course shell*, and the authoring program *authoring shell*. The diagram below shows how programs and database relate to each other:



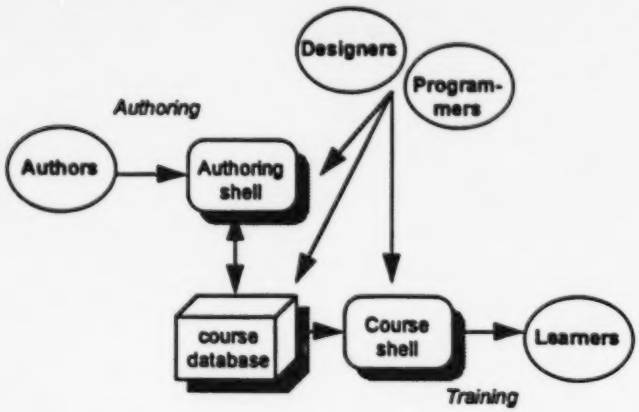
This approach makes it possible for non-programming subject matter experts to directly author the course, without being bothered by programming details. An important advantage is further that the course, delivered through the CBT, becomes highly maintainable, because at all times the authoring shell can be used to edit or extend the course.

It has to be said that, sometimes, a third program is built for CMI (Computer-Managed Instruction) purposes: an instructor shell. This program could for instance communicate with the course shell, using datafiles, to enable an instructor or coach to view registration and results of learners, and to pre-select certain course modules for them. However, this is not really a integral part of the building block approach.

Instructionally meaningful units
The building block approach requires fixing instructional transactions into software components, in a way which is specific for the requirements of a CBT project. Not only 'screen' level, but also levels above that (invisible), like modules, series of exercises, test or practice use of an exercise driver, progress registration, etc.

In the ECC Building Block approach, CBT is developed from an instructional design based on the application of a limited set of instructional units. These units are e.g. a type of presentation, a type of exercise (for instance multiple choice), but also higher level instructional units, like 'module', or 'menu', or 'registrate learner progress'. After this, in the functional design of the software, the instructional units are then translated into a number of units of 'drivers' (interface and code) combined with dataformats for the database (e.g. record structures). It has to be noted that in the software design, some drivers will be added to the 'instructional ones', based on software architectural considerations (e.g. defining a driver which

controls the running of a related set of lower level drivers), or on functional considerations (e.g. drivers that control initialization of the environment etc.).
Because the author shell uses the building blocks as well, the author can only enter data in the format which has been defined in the instructional transactions.



Reusable library, but customize

- re-using the existing library of building blocks, but still customize them for the specific instructional needs of a project.

Over the past 2 years, a library of ready-to-use building blocks has been developed. These building blocks have been made generic, so that they are easily reusable for new projects, by strictly enforcing coding and documentation standards. However, because of this generic nature of the building blocks, they are quite abstract and complex. Consequently, re-use of the building blocks is best done by ECC designers and programmers. Re-use by non-ECC developers will prove difficult and is not recommended.

Although the building blocks can be re-used directly, without any changes, it has been common to customize the building blocks, i.e. adapt them to the specific needs of a new project. The level of customization may be small, such as changing the place of a button, or a small change in the logic, or changes may be large, such as changing the user interface *style*, or changing the driver- and data structure. Because of the strong separation of interface, functionality and data, customization is relatively easy, and therefore always done.

The customization usually results from a sort of *negotiation* process between the wishes of the instructional designers and the feasibility of the software implementation. This negotiation process is done in the functional design phase, and is an important task of the functional designer. Thus, a good level of both customization and re-use is ensured.

The ECC multimedia toolkit

The ECC multimedia toolkit is an environment for developing advanced multimedia applications. It is a specific implementation where use has been made of the building block method. A choice has been made for a certain course structure, presentation functions and interaction functions. It is therefore a dedicated high level authoring environment.

The ECC multimedia toolkit consists of three major components:

- authoring shell: supporting the authoring process;
- instructor shell: supporting the instructors role like allocation of courses and registration;
- user shell the application for the learner.

Besides one needs:

- text, graphics, audio, video editing tools: these are tools for the author with which contents are being produced. These are generally available tools on the market.

Hardware and software requirements

The ECC multimedia toolkit is available for three levels of multimedia:

- Supporting text, graphics, stills, animations, audio, video:

This is based on DVI (Digital Video Interactive) or Video for Windows.

When using DVI, supporting full screen video one needs a DVI Action media board.
With Video for Windows no additional hardware is needed, except a voice card.

Furthermore the minimum hardware requirements are:

- a hard disk with at least 300 MB (1 minute of video takes about 10Mb, 1 minute of audio about 1 Mb in DVI mode)
- a mouse
- a 33 MHz personal computer with 80486 processor
- 8 Mb internal memory
- a VGA colour monitor
- VGA-board with Feature-connector
- Amplifier (with normal line Input) and headphones or active speakerset
- Window version 3.1

- Supporting text, graphics, animations, audio:

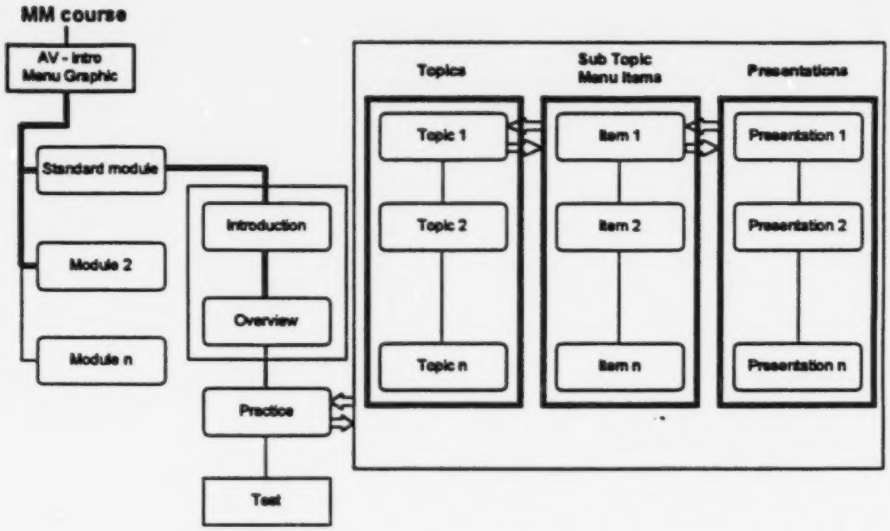
The same configuration as for Video for Windows

- Supporting text, graphics, animations:

No voice card needed, less mass storage (i.e. 100 Mb), eventually 80386 computer with 4Mb RAM.

Course structure

The structure of multimedia courses which can be developed with the ECC Multimedia toolkit is pre-defined. The following picture presents the structure of a course.



As one sees in the previous picture a course made in ECC-Multimedia Toolkit contains one or more modules. These modules can be a Test, Video or Standard module.

A Standard module consists of:

- Introduction
- Overview
- Practice
- Test

Introduction:

The introduction contains a text window with the objective of the module and (optional) a full screen introduction video clip. The objective text describes the goal of the module.

Overview:

This part of the module presents the main points of the module. These main points are presented in an audio fragment in combination with stills, graphics and text, a so-called 'audio page'. The objective of this overview is to give the participant a 'advanced organiser' for this module. In this part the content of the module is placed in a wider context and also the route trough the module is given by placing the different Topics on the screen.

107

Practice:
In this part of the module the participant must answer questions and can get more information by selecting presentations. These presentations are made by using the multimedia database. Hints can be provided for selecting the right presentation.

Test:
The test consists of questions without feedback. After the test a study advice will be given to the participant.

Multimedia database:
Information will be presented in a 'information bank' organised around the topics in the overview. Clicking on a topic in the information retrieval can give direct presentation or a sub menu with 'sub menu items'. Each item contains a presentation.

Presentations consists of audio pages, static pages or video pages and are presented in a window on the right-hand side of the screen. Video pages consist of an specific audio-video fragment.
An audio page contains an audio fragment (mostly a narrator speaking) with a series of stills, graphics or text. A static page is also an audio page with only one still, graphic or text.

The other module types are Test and Video module. The Test module contains only questions and no feedback. After the test the score will be presented. A video module contains a video fragment to be presented after a target text in a window.

Course definition
After one has started the ECC multimedia toolkit the computer presents a screen, in which one defines the course.

Here one can:
- edit the title of the course;
- define the language, in which the texts and buttons are being presented;
- select the video fragment, which will be presented as the trainees start-up the course;
- select a menu graphic, which will be presented after the opening video fragment. The module names are presented over the menu graphic;
- edit the dictionary (book), which contains explanations of relevant words used in the course. During the course the trainees can look up these words.

Creating and editing a module
Each module may consist of:
- introduction and overview;
- presentation organised in topics and items;
- standard tasks or exercises consisting of multiple choice, multiple select and matching assignments;
- task tests consisting of multiple choice, multiple select and matching assignments.

Introduction of a standard module
The introduction of a standard module is always presented to the trainees at the start of a module.
An introduction may consist of:

- target presentation;
- video presentation (optional);
- audio presentation (overview).

The introduction starts presenting the target text, which describes the objectives of the module selected by the trainees. Subsequently the course may show a video, which is followed by an overview of the module. This overview consists of an audio presentation combined with topic names, stills, graphics or text. The function of the overview is an 'Advance Organizer'.

An audio presentation can be combined with topics, stills, graphics or texts, which are shown in the list with scrollbars as filenames.

Creating presentations
The presentations are hierarchically organised. Each module has one or more topics, which may includes items. An item leads directly to a presentation.

There are three types of presentations one can create:
- video presentations;
- audio presentations;
- static page presentations.

Audio An audio fragment combines an audio fragment with a series of graphics, stills or texts, and can thus be compared with a 'slide show'. Such a fragment usually comprises of more than one page.
Static This is a presentation of one page containing graphics, stills, text or a combination of these images.
Video A video only shows an entire video fragment.

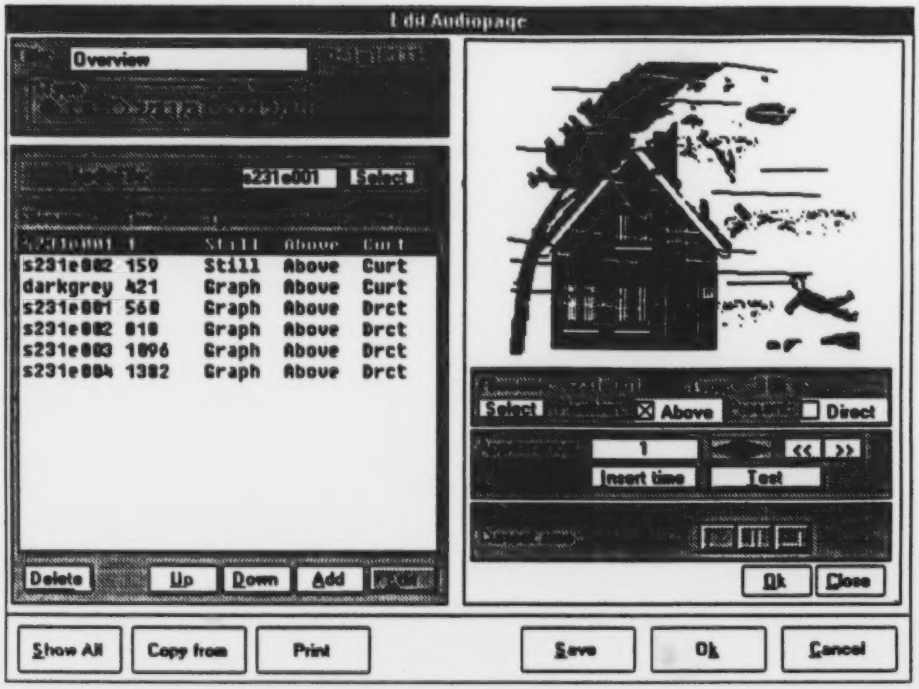
Editing presentations

Audio page
An audio page shows an audio fragment combined with one or more graphics, text or stills.

For each page one has to define:
- the filename;
- type of image (still, graphic or text);
- timing (the time of appearance of the image in the audio presentation);
- position on the screen (see below for type of lay-out);
- a visual curtain effect at the transition of pages.

109

Edit audio page

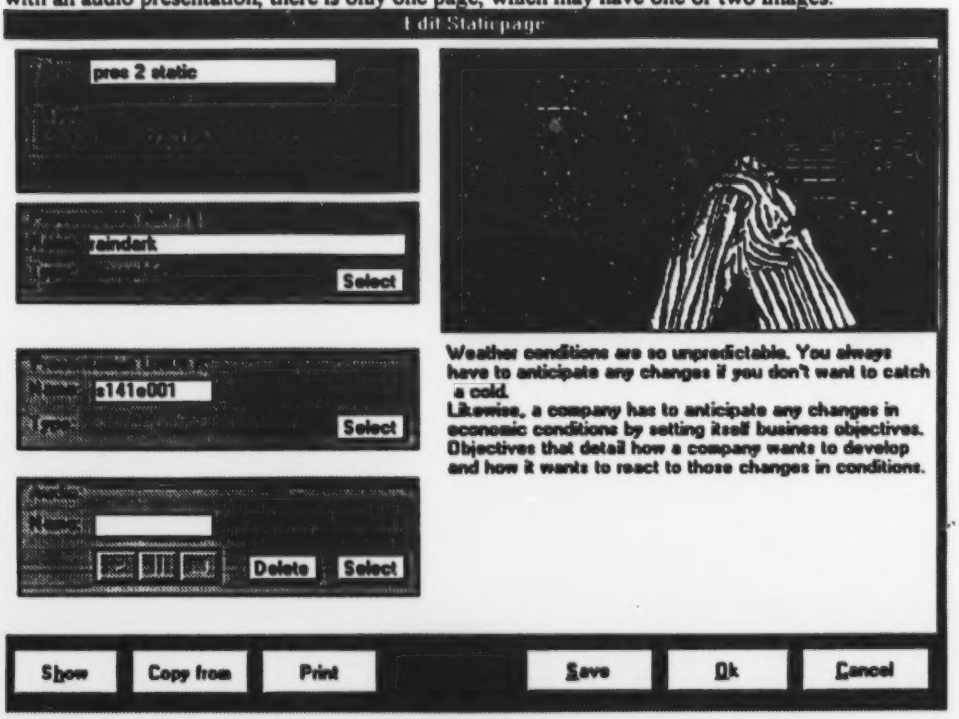


In this new window one can conduct the following actions:

Direct presentation	Show the transition of the current fragment to next one with or without a visual curtain-effect.
Test	Test the appearance of the previous and current page in the audiofragment. In the right window one seen the image and hear in the audio. During the test one are able to select the appropriate timeperiod of appearance via the button 'Insert time'.
Insert time	Change the timeperiod of appearance of the current fragment. The start of this timeperiod is determined at the moment one press on the button 'Insert time' during the test.
Play (>)	Play the audio presentation.
Pause (||)	Stop the audio presentation.

Static page

A static presentation is a presentation of a graphic, audio, a still image or text. In comparison with an audio presentation, there is only one page, which may have one or two images.


Edit Staticpage
pres 2 static
zaindark
Select
s141e001
Select
Delete
Select
Weather conditions are so unpredictable. You always have to anticipate any changes if you don't want to catch a cold.
Likewise, a company has to anticipate any changes in economic conditions by setting itself business objectives. Objectives that detail how a company wants to develop and how it wants to react to those changes in conditions.
Show
Copy from
Print
Save
Ok
Cancel

Video page

A video page is a presentation of running video (combined with audio).

Create exercises (task)

There are three instructional transactions available supporting interaction:

- matching;
- multiple choice;
- multiple select;

Matching

A matching exercise consists of two columns, which both contain words. The task of the trainees is to match the words in the two columns, which belong together. At the end the program checks the answer and offers feedback.

Multiple choice
A multiple choice exercise presents to the trainees a question text and 2 to 4 answer options. The answers can be presented as text or stills. The task of the trainees is to answer the question by selecting one option. The program checks the answer and offers feedback.

Multiple select
A multiple select exercise has an instruction text, a question text and two feedback texts just as the multiple choice has. The difference is that multiple select may contain more than one good answer.After a response the program checks the answers and offers feedback.

Create tests
Tests make use of the same three interaction types, multiple choice, multiple select and matching.

The instructor shell
Different participants can be connected to a course by using the instructor shell.
The instructor shell comprises of the following parts: authorisation, participants, install options and registration.

Extending the authoring environment

So far the multi media toolkit has been described with its specific functionality. What if one wants new functionality? One could specify and implement for instance new presentation forms, new interactions or new support functions and integrate them into the existing environment. Also editors have to be adapted then. However, if there are essential changes in the structure, one might build a new environment . Re-use will be made then of the lower level drivers. These drivers will often be customized to particular needs. Based on our experience one can say that re-use is often possible to 50-80%.
This approach has proven to be optimal in terms of development costs and client demands. We then compare this approach on one hand with making use of tools having no flexibility and on the other hand with developing each application from scratch with a regular programming environment.

Putting multimedia into practice

Mark Vegting

Abstract

In this paper, a description of how multimedia can effectively be used in practice is presented. Two applications are discussed, which were both developed for a touroperator. One introduction course and one course on basic sales skills. In both courses a combination of instructionally relevant multimedia information retrieval and questioning was used. Evaluation shows that the goals were met and participants were satisfied with the results.

The company

SUN International is a Tour operator, based in Belgium. The company operates in four different countries: Belgium, the United Kingdom, the Netherlands and France. The company started in the early fifties as a small one-man company, arranging transport for English travellers who came to Belgium. Later, they were transported from Belgium to the Mediterranean Sea and the Alps. Adding more and more services, the company grew larger. It began to organise the transport and activities itself. In the seventies, the company took over an important player in the Belgium travel industry. In the eighties many shares were sold, but the majority remains in the hands of the founder. Because of the developments in the travel industry and in the European Community, Sun International decided that it was important to become a real international firm. The capital that was drawn with the selling of the shares was invested in the take over of other companies, e.g. in the UK. The latest merger took place in 1992, also in the UK. Sun International now offers a great variety in travel industry services. From bulk travels to specialised city trips for a great deal of travellers. This is realised through a conglomerate of several separate companies. All these companies are part of Sun International, but operate under their own name. The name Sun International is reserved for several general, centralised activities.

The target population

In the entire travel industry, and SUN International is no exception to this, there is a relatively high turnover of personnel. This means that there is a continuous flow of new employees, who must be introduced to the company, but who also must learn the reservation system and sales skills.
There is a difference between the employees in the UK and on the continent. In the UK, the average level is secondary education. The target population can be typically summarised as 18 year old girls. Although there are also some men and some older women in their fifties. On the continent, the level of education is higher: most of the workforce has attended some years of higher vocational education. Consequently, the average age is higher: around 20.
In general, the employees only speak their own native language.

113

The need

Due to the rapid growth in the eighties and nineties, some reorganisations were necessary. The newly acquired companies and internal changes, combined with the high turnover-rate, led to the situation where many employees did not have a good overview of the activities of the company. Also, did they lack a feeling of corporate identity. They also were unable to position their own activities within the activities of the company.
Also, many employees were not sufficiently equipped to perform their tasks 100% well. Several causes were due to this: The rapid growth of the company, different reorganisations, and the desire to implement new management styles. The latter cause meant (amongst others) empowerment of the employees. The tasks of the employees were expanded. For example: the separate 'complaints department' was integrated in the sales-function. But also the reservation system that was used was going to be changed. Although the intentions of the management were good, the skills of the employees to perform all these tasks had not been upgraded adequately.

In general terms, the need for training can be summarised as follows:

- Lacking the insight in Sun International's corporate identity;
- Unclear organisation structure;
- Insufficient knowledge of the activities of their own company;
- Insufficient sales skills;
- Insufficient product knowledge;
- Turn over of new employees.

The objectives

The needs that were identified led to corresponding objectives. But Sun International also had additional objectives. For example, it wanted participants to regard Sun International as a company with a 'human face', a company that cares for its employees. To realise all this, two applications were developed: a 5 hours multimedia application to develop the attitude regarding the corporate identity, called SIIC (Sun International Introduction Course), and an 8 hours multimedia-application focusing on the product knowledge, systems knowledge and sales-skills, called SISI (Sun International Sales Introduction).
SIIC was to develop the feeling of a corporate identity and to explain the organisational structure, as well as the benefits of being part of a large organisation. The application introduced participants also to all the companies activities.
Both applications were created in two languages: English and Dutch. The French version will be created later.

The rationale

Why was multimedia chosen as a solution for the identified needs and this target population? The main reasons are the establishment of a corporate identity and showing a human face. A corporate identity is intangible. An important aspect of it however, has to do with the attitudes within a company. A positive attitude towards the company is inevitable of course. Situations in which attitudes have to be developed can very well be supported by using realistic images

and role modelling. Another reason was the motivational aspect of using audio and/or video. Above this, multi-sensory environments have a big impact on people, because it comes close to real world situations. This leads to easy association with own experiences and consequently better retention. Another goal of the application was to give the employees the feeling that the company cared for them. A multimedia environment, was a way to realise this.
Other arguments can be found in the business the company is operating in. The travel industry is very much visually oriented. Nice pictures of holiday destinations serve as the best selling argument. The employees are confronted with this every day. The application had to be connected to this way of presenting information. Another practical reason was that the library of photographs with Sun International was very big.
By making use of different media it was possible to make advantage of the medium that was most suitable for its purpose. Because running video (if at the right time) can have the highest impact on people, this was reserved for the most important elements of the application like the welcoming speeches and the presentations on the cornerstones of the company. Although pictures can tell more than a thousand words, it is in most cases very useful to have some additional explanation of the pictures. That is where narrators were used. If the narrator's information was really crucial for the participants, the story was supported by bullet points. All these media could be combined in one application on a PC. And alternation between the best suited medium led to an efficient, attractive application.

The application

Both SIIC and SISI are comprised of different modules. For SIIC, there are some general modules, which are the same for all employees, and one company-specific module. The company-specific modules, contain elements which only relate to the activities of that specific company. For example, the countries or cities they focus on, the brochures they use, the people who work there, etc.. These company specific modules will only be taken by participants who work with that specific company. After logon, the participants will be directed to those parts of the contents that relate to their company.

SIIC is comprised of eight modules:

- Pre-test
- Introduction
- The travel Industry
- The history of SUN
- SUN as a group
- Company-specific module
- Test
- You and SUN.

A pre- and post-test are included to be able to assess an increase in knowledge with the participants in their current knowledge about the elements that are covered in the application. These tests are comprised of 20 multiple choice questions. The first 15 questions of each test cover the general modules, where the last 5 questions are on the company-specific module. The pre-test appears only the first time the participant starts the application. After the participant has finished it, the participant is confronted with a main menu. Here, the participant is free to choose any module.

115

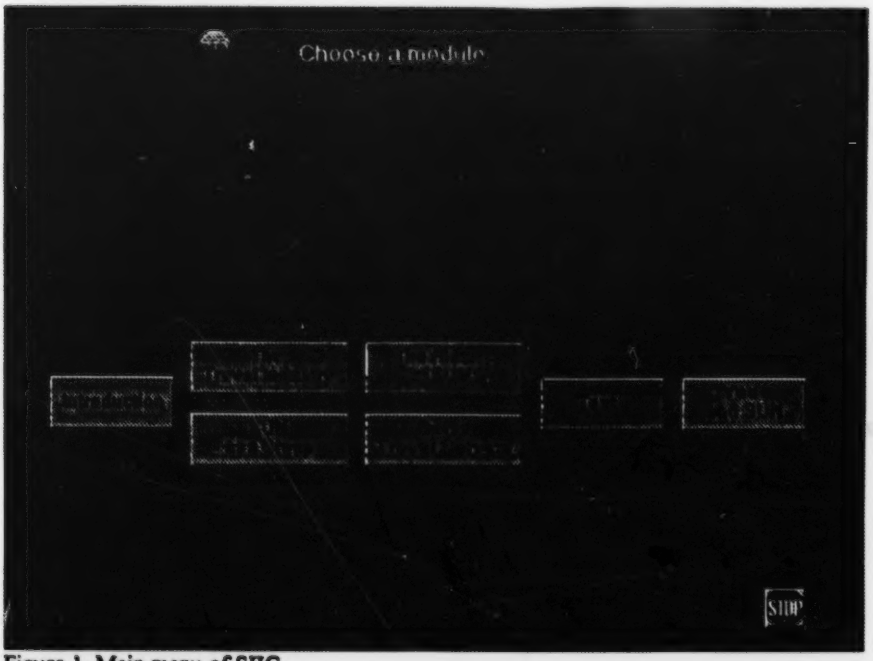


Figure 1. Main menu of SIIC

"Introduction" is the first multimedia module. 'Introduction' is a video in which the founder and chairman of the board of directors welcomes the new employee. The three cornerstones on which Sun International is based are introduced as well. This module is a linear video.
The modules "Travel Industry", "History", "Sun as a group" and "Company specific", all have the same structure. This structure is comprised of the following elements:

- Short audio/video-clip to gain attention: Introduction;
- Overview of the entire module, in which an advanced organiser is built;
- Practice, consisting of questions and information retrieval:
  - Questions regarding the contents (4 types: Multiple choice, Multiple select, Matching, Multiple choice with photos);
  - Information retrieval system to retrieve multimedia presentations on certain topics, providing relevant information to answer the questions;
- Module test. This test can only be taken after all questions have been answered.

The last module "You and Sun" is a second "welcome to the company". This time by the managing director of the company. This speech focuses more on the future of the new employee with the company and stresses the core values. The main goal of both modules "Introduction" and "You and Sun", is to show the human face of the company, and to realise the biggest impact on the participants.

The structure

Let's discuss the structure of the 4 modules in more detail. Look at figure 2.

Standard module:

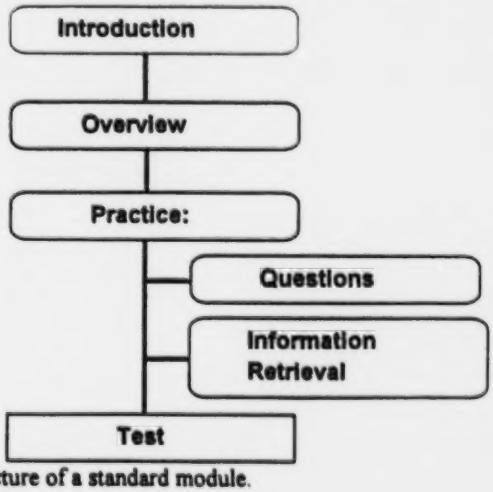


Figure 2: Overview of the structure of a standard module.

Introduction of a module
By clicking on the button for a module, the objectives of that module appear. When the participant wants to reach those objectives, (s)he continues. A short video clip is then started. Each module has its specific clip, which relates to that module. The "Travel Industry"-module starts with a collection images. Images of players in the travel industry, of holiday travellers, of types of transportation, of types of accommodation. These elements are all covered in more detail in that module. The module "The history of Sun" starts with a black and white movie, showing how the reservations in the early fifties were made at Sun International. "Sun as a group" shows musicians playing separately and combined performance of the whole band. This is to symbolise the added value of operating as a group. The company specific module starts with a similar collection of images as the Travel Industry, but the images are more focused on the activities Sun performs.

Overview/advance organiser
After the introduction of a module has finished, an overview of the main topics of that module is presented. This presentation is comprised of graphics and pictures, with a narrator explaining. This explanation is supported by keywords, which appear at the moment the narrator mentions them. This way, an advance organiser of the content of the module is presented.

Questions/tasks
After the advance organiser is built, the first question appears. All questions allow the participant two tries. Should the correct answer not have been given, the correct answer will be presented. Only when the correct answer is given, either by the participant or by the application, the participant is allowed to continue with the next question.

Multimedia information retrieval

Treating adult participants as adults who are responsible for their own learning and who are able to make choices is one thing. But also for adults just browsing through a database and looking at presentations that appear interesting, is not the most efficient way to learn. Although it can be effective. It is more efficient if the participants are guided in some way at their exploration of the data. The questions/tasks provide this guidance in the following way: A question is asked about a certain subject. The participant is unable to answer this question, but he or she knows that there is more information on this subject available in the database. The search for information is more guided in this way; the participant has a focus. If the information is hard to find, or if the participant makes a mistake, the feedback will explain where to find the correct answer. The participant has the bullet points of the advance organiser from the overview at his or her disposal. These bullet points can be selected, which leads to a menu. The items in this menu can be selected to get a presentation on that specific item. This can be a video, a series of graphics and photographs with a narrator, or text. Sometimes, the presentation appears directly after selecting a bullet point.

So, the participant has complete freedom in the exploration of the multimedia database.

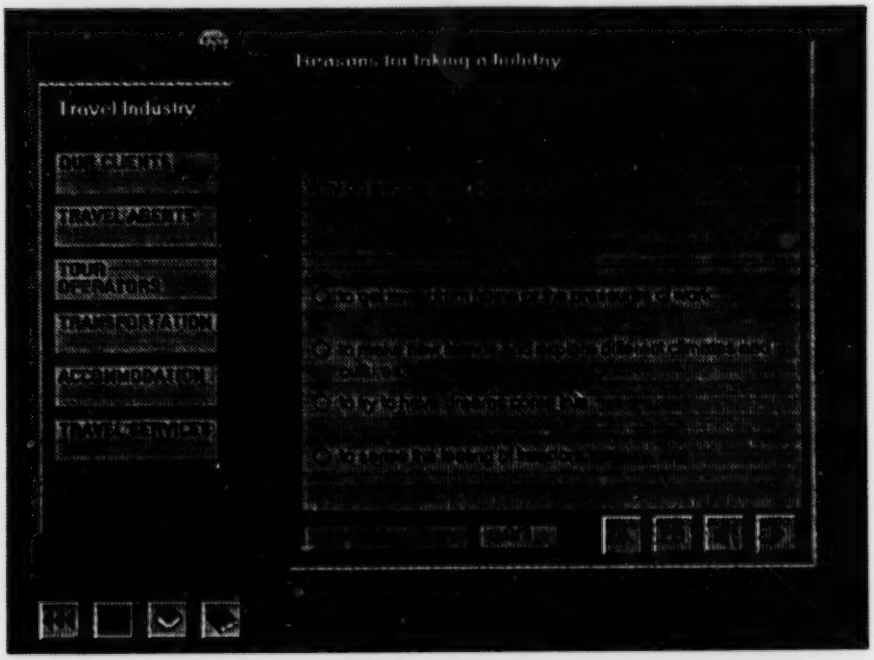


Fig.3. Overview of the main working area of a standard module: On the right the window for questions appears, on the left the buttons for exploring the database are available.

118

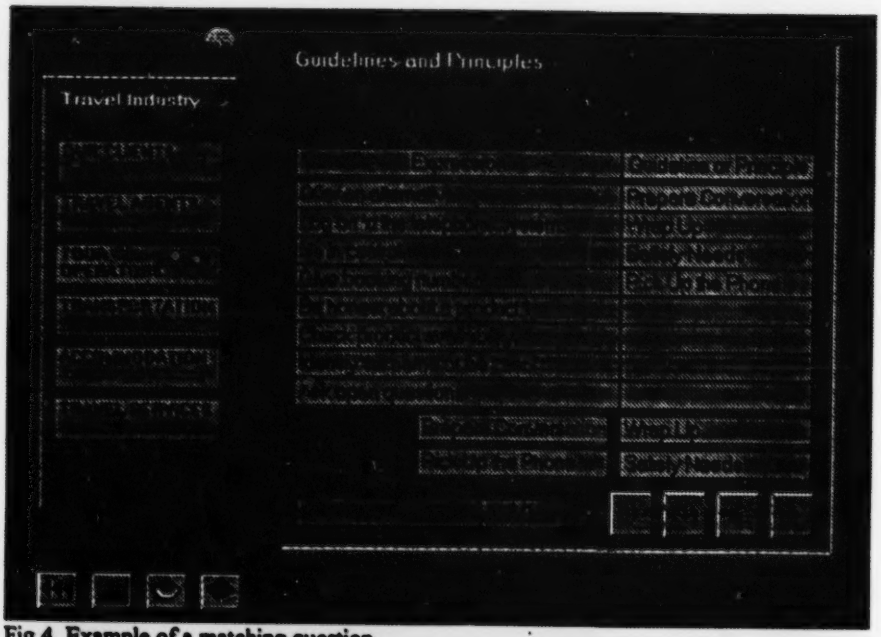


Fig.4. Example of a matching question

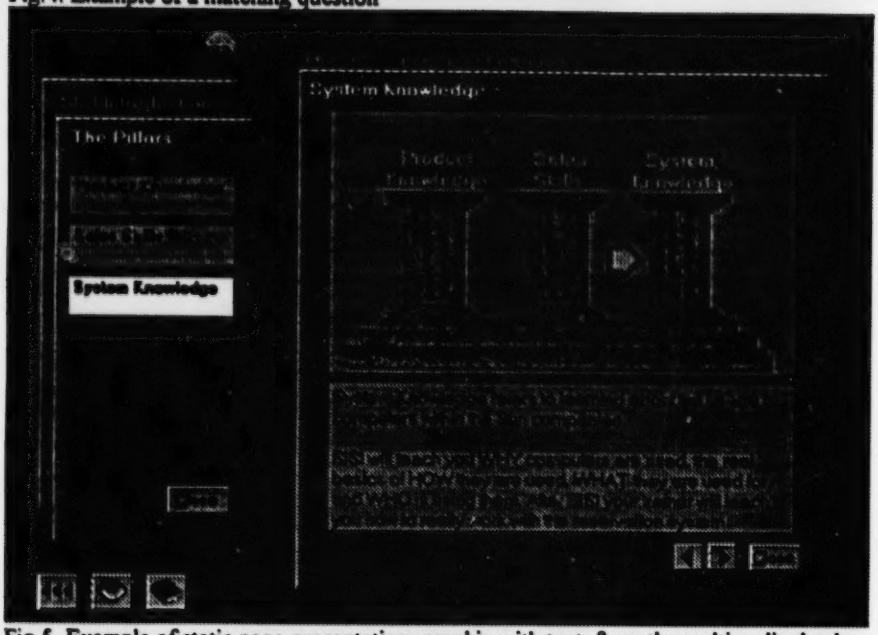


Fig.5. Example of static page-presentation: graphic with text, from the multimedia database. The window with the question remains available behind the window with the presentation.

BEST COPY AVAILABLE

119

The design and development process

At first a needs analysis was conducted by the instructional designer. The current situation was reviewed, including the current training situation and the current activities of the entire company. The main goals that the company wanted to achieve were identified and the way the training could support this. Interviews were conducted with the management of the company, and with employees, both existing and relatively new ones. The conclusion from this analysis, were the needs as listed in 'The need'.
The starting point for the design was that participants should be in control of the application. This was even more important because the participants are adults. The context (and the content) did not allow for simulations, but other options were possible. The focus of the application was on introducing new employees and establishing corporate identity. The content is therefore more in the affective than in the cognitive domain. This is not to imply that no cognitive activity is necessary, of course. Also, the module about the travel industry contains more facts, concepts and explanation than affective elements. But in general, this is true.
A team with the instructional designer, the technical designer, and the client decided that a multimedia information retrieval system would be used. But parallel to this information retrieval system, which allows free exploration, guidance and focusing was necessary. This was realised through the use of questions.

Visualisation
By choosing this parallel approach, it was relatively simple for the technical designer, to design the technical architecture. Although the two functions were available parallel, it was not necessary to transfer parameters from one element to another, or from one module to another. The difficult part was with the detailed instructional design. It was necessary to design/script interesting, short, relevant and understandable presentations. To establish the corporate identity, the three cornerstones of Sun International had to be present in most presentations. The length of the presentations was kept to 60 seconds maximum. Experience had learned that longer presentations were tiring, and participants did not remember what was explained. A multi-disciplinary team, comprised of an instructional designer, a technical designer, a graphical designer and a video director designed the entire application.
Three types of presentation were designed, called 'video page', 'audio page' and 'static page'.
Video pages are digitised videos and audio.
Audio pages are explanatory/interesting/ motivating graphics and pictures, supported by explanations by a narrator. The appearance of the pictures is timed with the digitised audio of the narrator.
Static pages are graphics or pictures with supporting written text instead of audio, or just a piece of text.

Authoring
Guidelines and templates for scripting were developed. This allowed employees from Sun International to script presentations as well. Also were they able to create questions by using a dedicated authoring system. Of course, it remained necessary for the instructional designers to review the presentations and questions, but a good mix could be established between necessary content expertise and instructional quality.
Because of this approach, and the technical architecture, it was possible to program the software parallel to the scripting and realisation of the presentations and questions. The people responsible for the contents did not have to wait until the software was ready. This meant a lot of gained time. Another advantage of this approach is, that maintenance is easier. Future

changes, which are continuous, are anticipated, and can be implemented easily. If necessary by the client.

The evaluation results

The scores on the pre- and post-test are registered by the application. These results give some quantitative information about the increase in knowledge. It gives no qualitative information however about the application, or the perception of it by the participants. To get some more information about this aspect, all participants filled out an evaluation sheet. For each module, participants can evaluate four aspects:

- The length of the module
- The relevance of the content
- The achievement of the objectives of the module
- Overall quality of the module

Each aspect could be scored on a five point scale [Excellent, Good, Fair, Marginal, Poor]

Although there are some differences between the modules, the general rating is very satisfactory. The length of the modules is by 85% of the participants regarded as Good or Excellent.
The relevance of the content of the modules is for some participants 'Fair' (15%), although still 70% of them rated the content at Good or Excellent. Most participants (85%) thought that the modules achieved their objectives, and the overall quality was also for 85% of the participants good or excellent.

The same questions are asked for the course as a whole, with more or less the same result. At this overall level, an additional question on the quality and appropriateness of the instructional materials and media is asked. The majority (55%) thought it was excellent. And 90% of the participants rated this question with Good or Excellent.
These results are rather impressive. The objective is of course to achieve a 100% score, but the achieved percentage makes the day of the designers and developers. It is a high score in training.

The participants had the opportunity to give their general remarks as well. Here, the general opinion is that there are some questions in the test that are not clear. Most people think it is a good introduction for new employees, although some of the current employees think that it may be too much information in a short time-span. Participants tend to like the module on the history of Sun very much. The content itself and the fact that it is explained in a multimedial way is perceived as very interesting.
Some people said that the course would not influence their motivation or attitude, because their interest is only with their own company. They did not want to be confronted with the fact that Sun International is a multinational company. On the other hand, some participants, e.g. from the bookkeeping department were very enthusiastic about these aspects. They were never confronted with these aspects, so it gave them a broader view on the company.
Most participants (and this is supported by the results on the tests) mentioned that they learned a lot. This is also true for participants who have worked with Sun International for some years.

121

Conclusion

The evaluation shows that most of the needs were satisfied. The participants all know the core values as they state in their remarks. The structure of the organisation has become more clear. It gives participants a good perspective of the activities that the company performs.

122

Adaptable Educational Computer Simulations

Willem Jaap Zwart, Albert F.J. Rhemrev, André M. Berloth

Introduction

Using interactive computer simulations, learners can explore a domain by conducting experiments and observing the effects of these interventions. In this way the learner gains insight into the dynamic behavior of a system. Educational computer simulations consist of a mathematical model representing the real system and an educational representation of the system in which the possibilities to intervene and observe are realized (van Schaick Zillesen, 1990). The instructional strategy commonly used with this kind of educational software is 'discovery learning' or 'exploratory learning'.
The use of this kind of computer simulation is generally recognized as having great potential for learning and instruction (e.g. Reigeluth & Schwartz, 1989), because it is expected to motivate, to invite the learner to actively discover the subject matter and to allow for unlimited practice in applying known concepts and in discovering relations. Essentially, computer simulation is a dynamic visualization of a system in the real world. An important design issue in the development of interactive computer simulations is the selection of visualization techniques used in the program. The selected techniques should be adequate representations of the shown phenomena and must be understood and interpreted by the learner. Furthermore, the teacher, in his role as second author of educational software, should be able to change the visualization of the system in order to adapt the simulation to the needs of his students and to increase the correspondence with his other educational materials.

In the Optical DataBase project (ODB-Project, Bestebreurtje & Verhagen, 1992) an attempt is made to develop methods and techniques for the design of reusable multimedia databases. These databases should be suitable for multiple target groups and multiple instructional strategies. Therefore, the teacher is allowed to change the content of the database and the instructional patterns for the learner. The databases are multimedia: text, computer graphics, video, sound and interactive computer simulations are integrated into one system.

The simulations implemented in this project allow for multimedia visualizations as well. An example of this kind of simulations is the renneting simulation (figure 1). The purpose of renneting is the separation of cheese material in the milk (casein-micelles) from the liquid portion (whey). This can be accomplished by the addition of a specific enzyme which causes the casein-micelles to stick together. The process is influenced by several factors including pH of the milk, temperature and amount of rennet and amount of calcium chloride added to the milk. The model is capable of calculating the changes in the milk with time. The calculated entities involve the amount of casein left in the milk, the amount of para-casein, the amount of para-casein that is matted together and the

viscosity of the fluid. The last variable is the most important indicator of the progress of renneting. The aforementioned influences make up a complicated system, in which the behavior is not easily predicted.

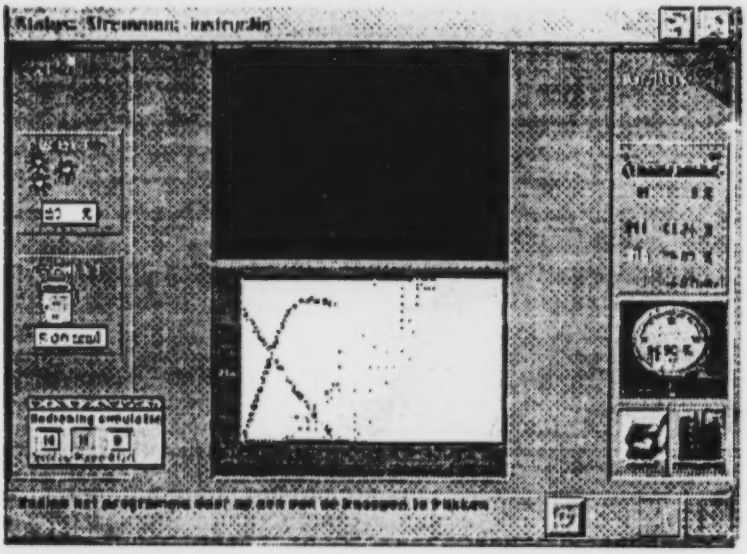


figure 1: the renneting simulation

The following visualization techniques are used in this simulation:
- graphs showing the change in variables
- digits, showing the current value of variables
- video segments used to illustrate the location of the process, the addition of the enzyme and to show tests which indicate the readiness of the renneting
- audio segments played at certain threshold values in variables

For the implementation of the computer simulations in the multimedia databases a flexible design system is developed using object oriented techniques. The working title of the system is OSS: Object-oriented Simulation System. An important part of the system is concerned with the selection of visualization techniques. The system allows for the connection of visualization tools to variables in the model. The selection of which tools to connect to a variable can be done by the teacher, prior to the use of the simulation, or can be done by the learner himself during run-time. This process of selection of visualization techniques can be done manually or can be executed with the help of a reasoning system.
This paper describes OSS in general and the display-manager, the part of the system responsible for the selection of visualization techniques in particular.

124

Instructional design for computer simulations

Instructional design theories aim at prescriptions for the process of designing instruction. Although educational computer simulations are seen as an important instructional application, instructional design theories for educational computer simulations are scarce. Especially the choice of visualization techniques is a issue that seems to be underexposed. Winer and Vázquez-Abad (1981) try to develop a theoretical framework for educational simulations. They state that educational simulations should "represent the actual variety of the system under study" (p.116). They observe that many simulations do not meet this requirement, thus severely constraining the range of interaction and the 'discovery' value of the simulation. They use the levels of knowledge representation of Bruner (symbolic, iconic and enactive), to describe the levels of interaction that learners should experience. These levels provide the learner "with a rich, integrated framework of knowledge on which to build a complete understanding" (p.116). The prescriptions for the use of visualization techniques are limited to the statement that graphic or pictorial representations can be easily incorporated.

The instructional design theory for educational simulations by Reigeluth and Schwartz (1989) focuses on a classification of educational simulations and the learning processes with these simulations. They distinguish:
- procedural simulations
- process simulation
- causal simulations.

These classes of simulations vary in learning goals and instructional strategies. The level of interaction allowed to the learners changes accordingly. In their view procedural simulations need the highest level of interaction and causal simulations the lowest. This level of interaction is expressed by the number of variables accessible to the learner. No prescriptions on the way of interaction are given.
In the area of learning processes Reigeluth and Schwartz distinguish acquisition, application and assessment. In the phase of application generalization, automatization and utilization are important. All of these processes need adequate visualization, but except general statements on the relation between fidelity and the prior knowledge of the learner, no prescriptions on this are given.

van Schaick Zillesen (1990) gives a general model of educational computer simulations (figure 2)

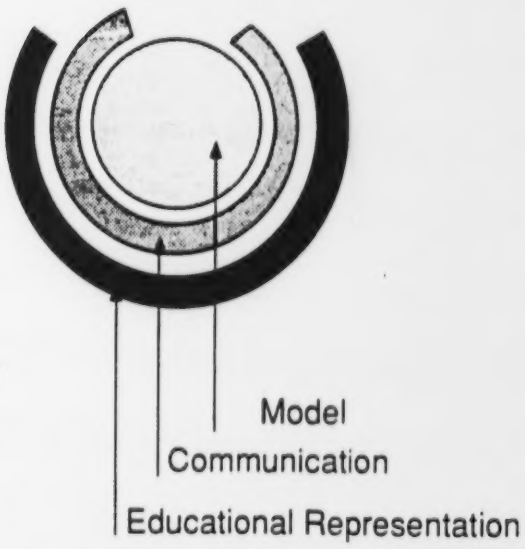


figure 2: general model of educational computer simulations

In this model the following parts are separated:
1 a mathematical model
2 an educational representation of the model
3 an interactive communication layer between components 1 and 2

The interactive communication layer arranges the following design decisions:
- the selection of variables to present to the student
- the way of presenting these variables
- the way the student can interact with the model
- the communication with other educational programs.

Van Schaick Zillesen emphases the division of labor during the development of educational computer simulations. A team of specialists in the area of modeling, didactics, graphical design and educational technology should cooperate in this development process.
He states (1991) that computer simulations have two main advantages above real experiments:
- visualization
- didactics.

Visualization of abstract systems with a set of objects which can be observed and manipulated eases the construction of a mental model of the system. Although it is not clear from his model of educational simulation whether the actual visualization takes place in the educational representation or in the interactive communication layer his separation between model and representation is a useful construct in making computer simulation adaptable in this respect.

In the second generation instructional design model (ID_2 by Merrill, Li and Jones (1991) a similar separation of domain knowledge and representation is proposed. The instructional transaction theory assumes that the lack of separation in current authoring tools is the main reason for the high development costs of educational software. They propose a library of 'transaction shells' which are reusable software components suitable for a certain type of educational goal. Every transaction shell consists of an implemented abstract instructional algorithm. This abstract algorithm can turn in to a concrete educational application by filling the transaction shell with:

- **a knowledge base**, a system independent description of the subject matter
- **a resource database**, containing system dependent representations of the subject (e.g. pictures, sounds etc.)

and

- **a database with instructional parameters**, describing for instance the sequence of the subject matter components and the instructional strategy used for these components.

Each database should be created by a specialist. The knowledge base by a subject matter expert, the resource database by media experts and the database with instructional parameters by an educational technologist. For the construction of the knowledge base a syntax is given (Jones, Li & Merrill, 1990) consisting of three types of frames (entities, processes and activities) with four kind of elaborations (attributes, components, hierarchies and associations). Examples of instructional parameters are given for one instructional algorithm. Every transaction shells should however have its own instructional parameters. Furthermore, it should be possible to change the parameters during the delivery of instruction based on student model. Sample instructional parameters in the 'portray knowledge' group are concerned with the representation of the system (Merrill, Li and Jones, 1992):

- **view** (with possible values structural, physical and functional) indicates the principal way the knowledge is represented
- **mode** (with possible values language, symbolic and literal) refers to the nature of a view
- **fidelity** (with as possible values the range [low ..... high]) refers to how close the representation resembles the real thing.

No prescriptions for the content of the resource database are given.

Applied to educational computer simulation and integrated with the model of van Schaick Zillesen the following match can be made (Zwart, 1992). For educational computer simulations:

- the knowledge base should contain a mathematical model of the system
- the resource database should include certain representation techniques to visualize the behavior of the model
- the instructional database should included parameters for the selection of appropriate visualization techniques.

From this it is clear in which part of a flexible educational computer simulation system the selection of visualization techniques should take place.

Collis and Stanchev (1992) pay attention to *visualization*, *interactivity* and *intelligence* as trends in computer based educational simulations. Although their paper addresses these issues in the context of micro-computer based laboratories (MBLs) the trends are

applicable to educational computer simulations based on mathematical models as well. With respect to the visualization in computer simulations they observe an increase in quality and quantity of visualizations. The speed of appearance and the graphics in simulation software are improving enormously. Integration of simulation with interactive video is used more and more. They distinguish five major types of visualization:

- still and moving graphics
- sketches and drawings
- digitized photographs
- animations
- moving video.

Collis and Stanchev sketch a cognitive-instructional grid including simple to more complex cognitive skills and different instructional strategies ranging from motivating learners to stimulation higher order thinking. In the mapping of visualization techniques on this grid they assume that "more and moving is better in terms of visualization, ... no matter where one is on the cognitive-understanding grid" and that the more complex the instructional task the more complex visualizations are desirable. These general assumptions are then refined upon by the hypothesis that complex visualizations are particular useful for orientation and motivation (simple tasks) and for higher order thinking (complex tasks), but the more simple visualizations are suitable for enlarging knowledge and problem solving ("middle" tasks).

Min (1992) states that "a complete simulation learning environment consists of a series of elements, the most important of which are:
- highly visualized, graphical output
- highly visualized, conceptual, underlying mathematical models...." (p. 177).

He argues that different kinds of visualization and presentation should be presented to the learner *parallel*. As visualization techniques he names a conceptual scheme of the model, output curves and "video-messages" as feedback. The wide range of different kinds of visualizations range from abstract to concrete. However, no prescription on the selection of these techniques is given.

We can conclude that current instructional design theories give little explicit prescriptions on the selection of visualization techniques in educational computer simulations. We doubt if in the future general applicable prescriptions will appear. Too many characteristics of domain and learner are involved in this selection. The rather limited results of research in the area of interaction between treatment and aptitude directs us towards more flexible learning environments in which design decisions can be made in a later phase of the life cycle of educational software. The best thing to hope for in the near future are hypothesized guidelines, which need to be proofed by experimental research.

Consequently, our system for the development of educational computer simulations is flexible in the choice of visualization techniques.

The system allows for adaptation, both in the preparation of a simulation by a teacher and during the use of the simulation by the student, in:

- which variable to display
- which parameters can be changed
- how parameters and variables are visualized
- what should happen during the simulation run
- which model to use

Set-up of the system

The goal of our Object-oriented Simulation System (OSS) is to ease the development of adaptable interactive educational computer simulations, that can be integrated within multi-media databases. Therefore, OSS has a strong separation of tasks over software components, which can be configured separately. The communication between the components is standardized. Components can be implemented in different programs, using multi-tasking techniques. Although it is not the main development goal of OSS, the combination of a strong separation of tasks and a standardized communication protocol allows for flexible configuration of components into a simulation environment as well.

Our system is divided into three main components:

- the model manager, which handles calculation
- the interaction manager, which handles the interaction and visualization
- the communication manager, responsible for all communication between components.

The whole system is managed by the simulation manager. Furthermore, other programs can communicate with the simulation. For example an instruction manager can change the simulation during run-time or deliver additional domain knowledge. This allows an instructor to interact with the model and the students.

The minimal simulation environment consists of one model manager, one communication manager and one interaction-manager. However, it is also possible to let more models communicate with one interaction-manager, to let more interaction managers display the results of the models or to add other managers to the environment. All the different components talk to each other via the communication-manager: they only need to understand the language the managers use. The separate components of a simulation environment need not to be running on one and the same computer. The communication implementation allows components to communicate over a network. This allows for instance more than one student to work on the same simulation.

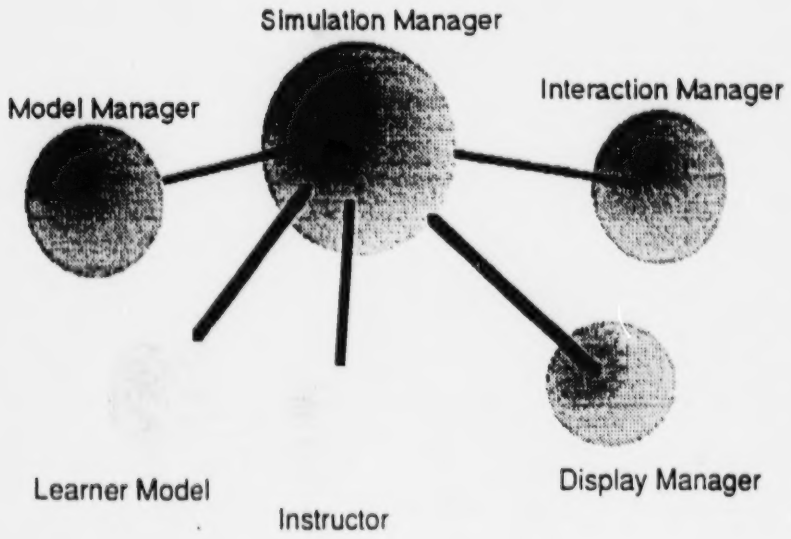


figure 3. general set-up of OSS

The interaction manager is the only manager that communicates with the user. For this purpose the interaction manager has 'interactors'. Each interactor has one input or output function. Every interactor has attributes that can be changed like its location, its color, its name etc.
The system is designed using Object Oriented Techniques and developed on a Apple Macintosh using C++ and MacApp. The communication system is implemented using Apple Events.

An example of non-standard component that can be used is the scenario-manager. This manager adds dynamic to the simulation. This manager makes it possible to let the simulation environment take actions triggered by conditions. Sample conditions included:
- the value of variable
- the change of a variable
- the comparison of two variables

Actions that can be executed included:
- the change of the value of a variable
- the execution of a model command, like Start, Stop and Pause
- the change of an attribute of an interactor

The information the scenariomanager needs is available in the communication protocol. The developer of the simulation simple makes a file with the actions and conditions and the simulation will behave accordingly.

```
# comment: simple sample scenario
if amount > critical_amount     start
while amount < 9                color of graph_1 is "black"
while amount < 9                max of graph_1 is 20
while amount < 9                min of graph_1 is 1
if dAmount changes              continue
if dAmount > 4                  store "phase1"
if pH is not -2                 goto "phase1"
if time > 12                    hide clock
if realtime > 15                show help
```

figure 4: sample simulation scenario

The interaction manager is capable of displaying a variable using some 30 kind of interactors, including VLP-stills and running video, audio-feedback, the normal graphs and indicators, animated input etc.

Adapting the representation

The display manager (an extension of the interaction manager) is the component of the system responsible for the selection of visualization techniques.
Its first main task is to add, delete and change interactors on the screen and to connect them to variables in the model. This task is implemented by giving commands, using the communication manager, to other parts of the system.
This mechanism allows the user or teacher to select a specific visualization technique for a specific variable directly.
Besides this direct interface a reasoning mechanism is implemented that can be used to select the most appropriate visualization technique based on characteristics of the domain, the learner and the visualization technique. By using characteristics a more abstract level of selecting visualization techniques is realized. The developer does not need to specify a visualization technique for every variable/learner combination, he just specifies the characteristics. The system is than capable of advising the user in the choice of visualization techniques. Figure 5 outlines the way this is implemented.

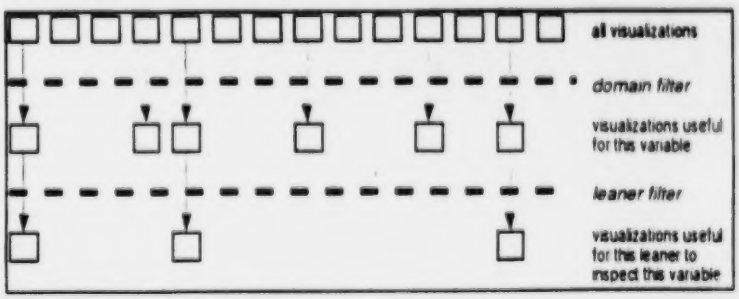

all visualizations
domain filter
visualizations useful for this variable
learner filter
visualizations useful for this learner to inspect this variable

figure 5: outline of selection algorithm

The interactors, learners and variables are all characterized on the following items (Zwart, 1992):

- Output-mode (enactive, iconic, symbolic)
- Order of presentation (zero, first, quantitative)
- Time-dependency (momentous, dynamic)

The output-mode variable is based on the representation levels of knowledge by Bruner. For interactors it indicates the level of representation used as visualization technique. For learners it indicates the level of representation the learner can understand. For variables it indicates the preferred way of representing the variable.

The order of presentation variable is based on research by White & Frederiksen (1989). It describes the form in which relations are shown to the learner. In the zero order presentation only the presence or absence of a phenomenon is shown. In the first order presentation the direction of change in the phenomenon is shown and in the quantitative level the exact value of the variable is shown.

Learners, variables and interactors can have more than one value of a characteristic. For instance learners can be able to interpret both enactive and iconic representations or a variable can be shown momentous and dynamic.

Visualization techniques come in two forms. The first are standard techniques, that do not need additional (domain dependent) resources. Examples of these standard techniques are graphs, bars etc. All that is needed to use these techniques for displaying a certain variable is a connection between the interactor object and the variable. The characteristics of these techniques are set within OSS. The other kind of techniques do need additional resources. Examples are video segments and animations. Every visualization of this kind needs to be labeled separately.

The list of characteristics can be expanded.

Currently the algorithm is binary: a visualization techniques is either suitable or not suitable for this learner/domain combination. However, using the same labeling of visualization techniques, learners and variables with another algorithm a ranking of the appropriate techniques can be realized.

The current implementation of the display manager allows the user to change or add a visualization technique for a variable. Whenever a selection of visualization tools is needed the reasoning system builds a list of appropriate techniques, from which the user can select one item. Figure 6 shows a sample outcome of the selection process.

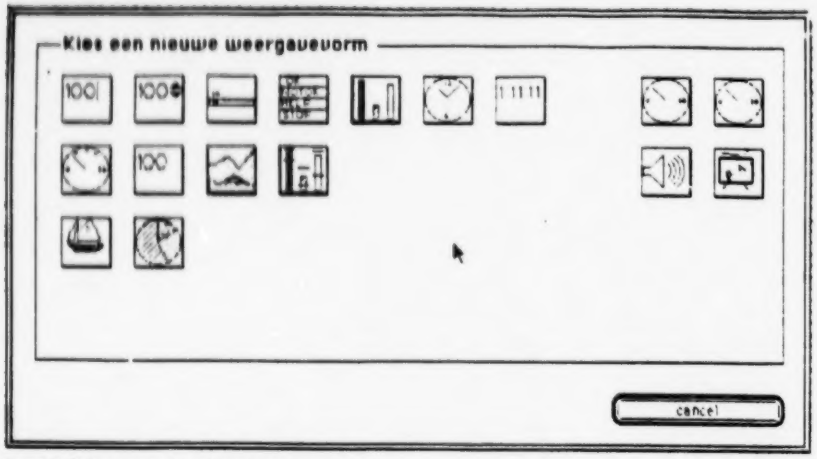


figure 6: Selection window of the display manager

Conclusions

The techniques implemented in the display manager of OSS provide a semi-automatic tool for the selection of visualization techniques. The labeling of learners, visualization techniques and elements of the domain allow the developer of educational computer simulation to specify attributes on a higher level. The characteristics can be seen as instructional parameters as introduced in the Instructional Transaction Theory.
With the absence of a prescriptive theory of visualization this system realizes the flexibility needed for adaptable educational computer simulations.

References

Bestebreurtje, R.B. & Verhagen, P.W. (1992). Developing the concept of an instructional multimedia databse for multiple targetgroups. Paper presented at the AECT-convention "Capture the Vision", Washington D.C.

Collis, B. & Stanchev, I. (1992). Trends and Techniques in Computer-Based Educational Simulations: Applications to MBL Design. Paper presented at the Microcomputer-Based Labs, Educational Research and Standards, NATO, Advanced Research Workshops, 9-13 November 1992, Amsterdam.

Jones, M.K., Li, Z. & Merrill, M.D. (1990). Domain Knowledge Representation for Instructional Analysis. Educational Technology, 29(10), 7-32

Merrill, M.D., Z. Li and M.K. Jones (1991). Second Generation Instructional Design (ID_2). Educational Technology, 30(2), 7-14

Merrill, M.D., Z. Li and M.K. Jones (1992). Instructional Transaction Shells: Responsibilities. Methods and Parameters. Educational Technology, 32(2), 5-34

Reigeluth C.M., & Schwartz E. (1989). An instructional theory for the design of computer-based simulations. Journal of Computer-Based Instruction, 16(1), 1-10.

van Schaick Zillesen, P.G. (1990). Methods and techniques for the design of educational computer simulation programs and their validation by means of empirical research. Ph.D. Thesis, University of Twente, Enschede.

van Schaick Zillesen, P.G. (1991). Ontwerpen van Educatieve Computer-simulaties. In: S. Dijkstra, H.P. Krammer & J.M. Pieters (eds.) De onderwijskundig ontwerper. Amsterdam: Swets &Zeitlinger B.V.

White, B.Y. & Frederiksen, J.R. (1989). Causal models as intelligent learning environments for science and engineering education. Applied Artificial Intelligence, 3, 167-190.

Winer, L.R. & Vázquez-Abad, J,. (1991). Towards a theoretical framework for educational simulations. Simulations and Games for Learning, 11(3). 114-119.

Zwart, W.J. (1992). Instructional Transaction Theory applied to Computer Simulations. Paper presented at the European Conference on Educational Research, 22-25 june 1992, Enschede

Multi media technology

135

A look at Multimedia

Jan Evers

Abstract

Multimedia land is not getting any clearer, lately. More and more the innocent PC-user runs into names like Multimedia PC, Video for Windows, Indeo, CD-I, Quicktime and DVI. What do these names mean, and what possibilities do they offer? This paper attempts to give an insight in the world of multimedia by describing the most significant possibilities of the use of multimedia.
The application of multimedia requires a high capacity delivery system. Therefore, firstly the definition of multimedia applications and the display system requirements will be discussed. After that, a description of the most important multimedia platforms will follow: Multimedia PC (MPC) with Video for Windows and DVI, Apple Macintosh with Quicktime, Philips' CD-I. It is expected that MPC will play the largest role on the market. Therefore the final part of this paper will investigate the possibilities of this platform.

What is multimedia ?

A multimedia application is defined as a computer application in which more than one of the following information or media types are integrated: text, graphics (animations), sound and video. A lot of the existing computer applications present both text and graphics. They are not called multimedia, however. Multimedia usually is not recognized as such until audio and/or video are being used.
The high demand on computer hardware is a result of the application of audio and even more: of video. The amounts of data are that large (video: approximately 10 Mb per minute) that the need for faster computers with more internal memory (RAM) and more storage capacity increases. A PC based on a 80386 processor, 4 Mb RAM and 200 MB hard disc is not extravagant. Moreover, the presentation of acceptable quality audio and video requires additional hardware, existing of boards.
The requirements for hardware used for development of multimedia requires even higher: with these computers audio and video delivered in an analog way from CD or videotape have to be converted into a digital representation on the hard disc. Acceptable development hardware is equipped with e.g. a 80486 processor, 8 Mb RAM and 1 Gigabyte hard disc. Quite often the digitising of sound and video requires also additional hardware (boards).

Different platforms

A large number of platforms for displaying multimedia applications is available on the market. The most important multimedia platforms will be discussed here, after that the PC-platform will be described in more detail. At the moment the most important platforms are: Multimedia PC (MPC) with Video for Windows and DVI, Apple Macintosh with QuickTime, CD-I by Philips.

The main difference between CD-I and the other platforms mentioned is the fact that CD-I uses a very specific display device: the CD-I system. This system can also be used to play-back audio CD's and Photo CD's (Kodak). Connecting the CD-I system to a television set is necessary to view a CD-I application. The CD-I application is operated by using a joy stick or infrared remote control. A keyboard is not incorporated. A CD-I application is stored on a CD, which implicates that it is not possible to update or replace e.g. a part of the video in the CD-I application. In order to do this, the entire CD has to be produced and delivered once again.

A multimedia application developed for MPC or QuickTime can be displayed using a standard platform (PC respectively Macintosh) under a standard operating system (DOS/Windows respectively System 7), which means that all the other facilities offered by those systems are available. Examples are wordprocessing facilities, database management, etcetera. Because of the fact that the MPC and QuickTime both use the standard file structures of the platform, it does not matter if these files are stored on hard disk, CD-ROM or on a network. Putting all files for a multimedia application on hard disk offers the advantage that replacing those files by new versions is easy. In this way the updating of e.g. audio or videoparts is very convenient. An other advantage of using the hard disk in stead of a CD-ROM is speed. The displaying of sections of video can start much quicker when using a hard disc than when these fragments are stored on CD-ROM. Also, because of the higher speed of the harddisc, video played from hard disk often can have higher quality, at the cost of more discspace. Using CD-ROM limits the user to a maximum of about 10 Mb of video per minute. Extracting larger amounts of data per minute is not possible, because these amounts can not be read fast enough from CD-ROM. Recently double end quadruple speed CD-ROM players came available, which make play-back at higher data rates possible.

The advantage of CD-I is the relatively low priced display device: about f 1500.- A good quality multimedia PC will cost approximately f 6000.- to f 10,000.- (when equipped with a large hard disc, 80486 processor, 4 Mb RAM, perhaps a DVI-board). This PC can also be used for other purposes, however.
The investments that have to be done to develop multimedia applications using CD-I technology are much higher than the investments needed to work with both other platforms. Software tools for CD-I cost thousands (or tens of thousands) of guilders, while the costs for tools for the other platforms are significantly lower. Designers Work Bench (DWB) by Scrypt Systems Inc. is an example of a complete development system for CD-I. The system including all required hardware and software (authoringsystem) costs f 86,850.- The authoringsystem offers possibilities to add C-routines.
The CD-I development process is complex. Digitized files have to be made using a PC, Mac or Sun. After that the files have to be converted into CD-I fileformats. Then the CD-I application can be developed using a CD-I programming environment. Finally, all digitized files and the application have to be merged and tested with CD-I emulation software, disc-set up software and test software. This final step often requires expensive extra hardware. When the application has been developed, a master tape has to be made to produce the actual CD-I's.
Full screen, full motion (screen filling and 25 frames a second for PAL, the European tv-system; 30 frames a second for NTSC, the American tv-system) video to be used with CD-I nowadays can not be produced in house yet. The videotape has to be sent to a third party, for digitizing.

Multimedia on PC

Although Macintosh with QuickTime is this moment's most advanced platform, the Multimedia PC (MPC) market share is rising fast. Without any doubt, the MPC market will be a large, if not the largest, market for multimedia applications. For a major part this is caused by the tremendous effort Microsoft is putting in making a success of the MPC. At this time Macintosh with QuickTime mainly differentiates in offering better tools to the multimedia application developers. Making animations and adding video still is much easier on the Macintosh compared to the MPC. However, this seems to be a matter of time.

The minimum technical specifications for the MPC have been defined by Microsoft, IBM and Intel, among others. The specifications are: 10 MHz 80286, 2 Mb RAM, 30 Mb hard disc, CD-ROM device, VGA video board, (16 olours), audio board, mouse, Windows with multimedia extension (standardized in Windows 3.1). Note that these specifications really are the minimum. Efficient usage of Windows requires a 80386 processor, combined with 4 Mb RAM. The usage of video requires even more: 80486, 4 Mb RAM, 200 Mb hard disc and VGA board with 256 colours. The Windows multimedia extension offers very easy possibilities to create and display digitized audio.

A CD-ROM device always is incorporated in the sale of a Multimedia PC or a so called MPC upgrade kit. When you decide to upgrade your PC to be able to work with multimedia, it is strongly recommended to buy a CD-ROM device. More and more the multimedia applications are delivered on CD-ROM, because of the large amount of data they consist of. Often the possibility exists to install an application from CD-ROM instead of from floppy discs. Also data intensive applications, such as manuals and (multimedia) dictionaries, are often delivered on CD-ROM.
Because 10 floppy discs for one application no longer is exceptional, installing from CD-ROM is much more convenient. Installing those amounts of data on hard disc is not recommended. All in all buying a CD-ROM device is worth the while, especially taking into account the decreasing costs. By now prices have gone down below fl 1000.-

In the beginning of 1993 Microsoft introduced Microsoft Video for Windows, an extension of the multimedia possibilities of Windows 3.1. Video for Windows allows the display of digitized video without the need for extra hardware in the PC. This is called 'software-only' video. (The play-back of the sound accompanying the video requires an audioboard, however.) The quality of the video that is being displayed, depends on the powerfulness of the display device: a smaller video window and less frames per second on a less powerful display device. This means that on a 80486 PC 25 frames per second can be displayed in a 160x120 pixels window. In a 320x240 pixel window (4 times as big) only 10 frames per second can be displayed. For 'software-only' video a VGA board with 256 colours is the minimum. The 16 colours of a normal VGA (board) offers no acceptable video quality.
A developer of Video for Windows applications has to buy Video for Windows (fl 500.-). The tools for digitizing video are included in the package. The libraries required for displaying Video for Windows files are distributed freely with the application developed. Therefore it is not necessary for the user to buy extra software to display Video for Windows applications.

Video for Windows offers the possibility to install other compression/decompression algorithms (codecs). An example is the Indeo codec by Intel. In displaying files made with

Indeo Video for Windows uses Intel's DVI (Digital Video Interactive) delivery board, if available. If this is not the case, the Indeo files are displayed by the processor (e.g. 80486). The size of the display window and the number of frames per second are being adjusted to the power of the processor available. If the DVI delivery board can be used, the Indeo files can be displayed full screen , full motion (640x480 pixels, 25 frames per second). The sound is always displayed by the special MPC audio board, regardless of the availability of the DVI board. A disadvantage of Indeo is the fact that it is not possible to display stills (yet). Stills are digitized pictures, slides or pictures from a video. They need a higher resolution than a videoframe, because the eye is more critical for stills than for moving video.
A DVI delivery board, the Action Media II Delivery Board, costs approximately fl 2500.-. Ace Coin in Great Britain markets a compatible board, the PCTV-SLC, for approximately fl 1400.- Digitizing video for both boards requires the Action Media II Capture Board. This board will cost around f 1000.-.

The maximum resolution Indeo video under Video for Windows can offer is 320x240 pixels. When higher video quality is demanded, it is possible to use the DVI delivery boards with the DV-MCI driver under Windows. By doing this, no use is made of Video for Windows and the accompanying file formats. The video, audio and stills (possible when using DV-MCI drivers) are being saved in DVI-files (so called AVSS-files). The highest quality video that can be presented in this way has a 512x480 pixel resolution, and is called Presentation Level Video (PLV). An advantage of using DVI with DV-MCI is that an extra audioboard no longer is required. Sound is being played from the DVI delivery board. A disadvantage is the impossibility to make PLV video files by yourself. Analog video, for example on a Betacom SP videotape, has to be sent to the video production company Teletota in Paris. Teletota is Intel-licenced to make PLV. To do this, it uses a large computer, that needs about 100 minutes of computing time to digitize and compress 1 minute of video

Digitizing and compressing 1 minute of video costs $ 250.-. However, it is possible to compress and digitize the video in house using the Action Media II Capture Module. This results in Real Time Video (RTV). RTV's maximum resolution is 256x240 pixels. The Indeo video quality (340x240 pixels resolution) is slightly better than RTV video quality.

Under OS/2, Presentation Manager, IBM offers a platform that is comparable to the Multimedia PC with Video for Windows platform: Ultimedia. This is a PS/2 system in which a DVI delivery board and a CD-ROM XA (eXtended Architecture; an extended version of CD-ROM) are incorporated. Here the multimedia extensions on Presentation Manager are available to the developer.

Concluding remarks

The Multimedia PC with Video for Windows plays an important role on the current multimedia market. Microsoft puts every effort in supporting this platform and making it a success. Especially now that it is possible to use DVI under Windows, this platform is a good alternative for applying multimedia, both from a user's and a developer's point of view. Applying multimedia requires powerful hardware, however. The defined minimum specifications actually are not sufficiently powerful. Recommended is a 33 MHz 80486 PC with 8 Mb internal memory (RAM), 200 Mb hard disc and a CD-ROM device. For a developer's system a 1Gb (Gigabyte) hard disc is recommended.

QuickTime

Jakob Sikken

Introduction

This paper will discuss the possibilities of QuickTime in using digital multimedia. Digital multimedia gives you possibilities of using multimedia, that are not available with traditional multimedia (video and sound from an analogue source, such as laser disk player and the video recorder). It gives you instant access to every part of your multimedia material and you can combine parts to create the material you need for that student at that specific moment.

Data amounts
To make working with digital multimedia at a reasonable cost possible, image compression is needed. One screen image (640*480 pixel's) in 24 bit colour contains about 900 KB of data. Displaying one second moving video at 25 frames per second (PAL), this gives about 23 MB of data per second. One minute of moving data will need about 1318 MB of data. Only very expensive computer equipment can handle this amount of data per second. Luckily moving video can be compressed very well without losing to much image detail.

QuickTime

QuickTime is a architecture
QuickTime is a platform-independent architecture for multimedia. Because QuickTime is an architecture and not a program, it is not the question if should you use either QuickTime or an other program, let's say AuthorWare. But you use both, AuthorWare^C(or something else) for the instruction part and let QuickTime handle the multimedia stuff. QuickTime adds the capability of working with multimedia to the system software. This makes it easy for every program to use multimedia, not only for commercial programs, but also for programs that you develop.

The QuickTime architecture performs four key functions:

1 synchronising a time-based data stream;

2 compressing data to minimise storage needs on the user's computers;

3 providing a standard graphical interface for creating, editing, and navigating through movies;

4 establishing a standard file format that accommodates dynamic information.

QuickTime can consistently play its multimedia files (called movies) at the highest possible quality, keeping sounds, images and colours properly synchronised on everything from low-cost personal computers to high-performance work stations.

QuickTime's modular design allows new capabilities to be added as quickly as they are developed. For example, as new methods of image compression are developed, you will be able to use them without any changes to the applications, simply by adding the new image-compression components.

Movie has a number of channels
A QuickTime movie contains a number of channels. There are three different types of channels: video channels, sound channels and command channels. A movie can contain any number of the three different types of channels. A movie does not need to contain moving video, it could just contain sound or only a command channel.
This makes it possible to have a sound channel for each language you want to have. You can use separate video channels for each type of screen, such as a black and white version, a Gray version and a colour version. An other possibility is different video material for different experimental conditions.

In a command channel you can put commands to synchronise actions of the computer with the video and/or sound material.

What can it do

Play, create and edit movies

Using QuickTime you can play movies, but also create and edit movies. QuickTime itself contains the basic stuff to create and edit movies, such as compressing and an interface for digitisers. The QuickTime starter kit for the Macintosh contains a program called "simple player", in which you can play and do some simple cut and paste editing on movies. But if you want more control and editing possibilities, you need a specialised program for creating and editing movies, such as Adobe Premiere or Diva VideoShop.

Still images
Multimedia is not only about moving video, but it can also be plain non moving video (still images). Where moving video consist of very large amounts of data, a number of still images can also be a large amount of digital data.

A part of QuickTime are the CoDecs or the components for compression and decompression of images. You can use these CoDecs both for compressing moving video and for still images. This gives you the possibility to store and therefore use a large amount of still images.

Photo-CD
An excellent example of medium containing a large amount of still images is the Photo-CD by Kodak. QuickTime makes it possible to access all the images on the Photo-CD in all the available resolutions. For the Macintosh the Photo-CD contains a lot of picture files neatly organised in different folders for the different sizes. The icon for each picture file is a small image of every picture.

Hardware needed

Currently QuickTime is available on Macintosh and Window PC's. It is announced for Silicon Graphics work stations.

Macintosh
QuickTime for Macintosh works with all 68020 or later Macintosh computers that have at least 2 MB of memory and are running either System 6.0.7 or any version of System 7 (with at least 4 MB of memory). This means that most Macintosh models, but not the 128 and 512 KB Mac, Fat Mac (Lisa), Mac ED, Mac Plus, Mac SE, Mac Portable, the Mac Classic and the PowerBook 100, can use QuickTime. All these models are out of production for at least a half year.

The faster the hardware is, the better the performance of QuickTime will be. But a essential part of playing a movie, the synchronisation of sound and video, will be kept on every Mac. It will skip frames to keep the sound and video synchrone.

Most of the available hardware to accelerate display of moving video will work under QuickTime. In the worst case you will have to recompress your movie to the compressed data format of the hardware accelerator.

The current version of QuickTime for the Macintosh is 1.6.1. This version has some bugs fixed of the 1.5 version, special decompression code for PowerBook displays (16 Gray shades) and a reduces memory usage. QuickTime for Macintosh is distributed free of any costs.

IBM PC's and compatible's
In our laboratory we have no experience with QuickTime for Windows yet, so the following information comes from the documentation (see reference list).

QuickTime for Windows runs on any 80386-based or higher system that has at least 4 MB of memory, an 80 MB hard disk, and a VGA or better graphics adaptor. Movies that include sound require a sound card. System software requirements include MS-DOS 5.0 and Windows 3.1 or later.

QuickTime for Windows consists of a set of Dynamic Link Libraries (DLLs) that provide all the functions necessary to play QuickTime movie files in Windows-based applications. QuickTime for Windows also provides Windows applications with the ability to display still images contained in Macintosh-created PICT files.

The latest version of QuickTime for windows is 1.1. This version contains the CoDec for using the compact video compressed data format. On the Macintosh is that the best one for normal video. It also supports OLE 1.0. QuickTime for Windows is distributed along with a number of QuickTime-aware applications for Windows.

By using QuickTime-compatible applications on both Macintosh and Windows system, users can interchange movies easily and enjoy a consistent user interface for working with multimedia. With hundreds of applications already supporting QuickTime for Macintosh, user can create and edit movies on Macintosh systems, then share them with colleagues, clients, and friends who have IBM-compatible systems.

The same movie can be played on both Macintosh and Windows systems, provided that it is self contained and has been set to be playable on non-Apple computers. Movies can be set for multiple platforms when they are created, or they can be converted using the Movie Converter software in the Macintosh QuickTime Starter Kit.

Software

To use the QuickTime functionality you can use QuickTime-aware applications. These are applications with build-in code for using QuickTime. Examples of such applications are Word Perfect, Microsoft Word, PowerPoint, AuthorWare and MacroMind Director.

For some other applications are external commands available to use QuickTime, such as HyperCard and SuperCard.

And for Macintosh applications that can handle pictures, there is an interesting system extension (or init) called "Wild Magic". This extension makes it possible to copy and paste QuickTime movies, while the application thinks it's handling a picture.

All applications, which fit the above mentioned descriptions, can play a movie with the standard graphic user interface. Some applications can do a lot more, such as controlling the playing of the movie from the application. It is possible to play only a part of the movie at any desired speed (within the hardware limitations) and direction. An other interesting option is to play a number of parts of different movies directly after each other, thus giving you the possibility to compose your movie at run time.

Creating movies

There are four basic steps in creating a QuickTime movie.

1 Digitise;

2 Edit;

3 Compression;

4 Adjust to storage medium.

Digitise
With digitise I mean digitising a video signal that comes from a video-camera or video-recorder. In this case you can use existing video material on tape. QuickTime offers a software interface to the digitiser and the program that controls the digitising process.

It is also possible to create a movie without a digitiser and let it be generated by the computer. This could be a good way the create an animation or a "movie screen dump".

Edit
After you have digitised your video material or generated it, most times it must be edited to get the right movies. Using editors you can cut, copy and paste the right video fragments in the right sequence. During this process you can use a variety of different transitional effects and special effects on the video and sound material. Adobe Premiere is such a QuickTime editing program.

Compression
As I have explained in the beginning uncompressed digital video gives you a very large amount of data to handle. This amount can be acceptable during the edit process, but in most cases it will not be acceptable on the target machines. So the digital data has to be compressed.

Adjust to storage medium
Just compressing the digital data might not be enough. This depends on the storage medium you intent to use. There are two aspects of this medium important for the compression methods. First is the data transfer rate of the medium. For most CD-players this is 150 KB per second, you can't get the best results if your movie needs 500 KB of data per second. The second aspect is the total amount of data you can store on your storage medium and the total number of minutes of movie you whish to use. Both aspects results in a desired number of KB data per second.

To reach the desired transfer rate, some times the movie has to be more compressed. There are a number of ways to get a higher compression. First there is the possibility to just compress it more by accepting a lower quality image. You can leave images al to gather out of the movies, resulting in a lower frame rate. An other way is to reduce the image size. Each of these ways have a lower quality result in common.

Expensive way of working
In the expensive and the fast way you do the digitising and the compression real time. To do this you need additional hardware for the compression. This hardware is expensive, but you save some money on the needed disk space and the time needed the create the movie. Indeo Technology of Intel can do this task, but only if you accept a lower image quality.

For the best possible image quality, with Indeo Technology, you need to send the video tape to a company for digitising and compression. This will cost you a few hundred dollars per minute of video. The Indeo Technology is available for both Macintosh and IBM-PC computers.

Cheaper way of working
A cheaper way of working is to do the digitising and the compression after each other. This can be done in two ways, the first way is to grab a single frame and then compress it. After it is compressed, grab the next frame and so on. This is a good way of working if you video material can be computer controlled accessed on a frame by frame base. This is true for the laser disk and for expensive video recorders (and the video tape must be prepared this operation).

The second way is to digitise the running video and transfer to data real time to the hard disk. Due to the limited transfer rate of hard disks and the channel to it, the data stream must be reduced. There a few ways of achieving this, do not use the full screen and do not use every frame. Working this way you can achieve reasonable results, for example an image size of 320*240, 16 bit colour (32000 colours) and 10 frames per second which gives a data stream of 1.5 MB per second.

An image size of 320*240 is only a quarter of the standard VGA or Mac II screen. But in the reality this is the highest achieved image size, even the DVI boards on the IBM-PCs and the EYQ boards for the Mac (both Indeo Technologies) use this image size. To get it full screen the image is enlarged. This is due to the way most digitisers work, they only capture one of the two fields out of a frame. A PAL video signal has 25 frames per second and each frame exists out of two fields. Each field skips every other line, it has only half the number (312 and 313) of lines a frame (625) has. This gives an effective refresh frequency of 50 images per second instead of 25 images.

Experiences

Playback experiences
We have some experience with QuickTime for Macintosh. We have found out that 16 bit colour (32000 colours) is necessary. The colour resolution of most computer displays, 256 colours to be chosen out of a pallet of 16 million colours (24 bit), is not enough for a good result. There are just not enough colours to make a good image. Therefore 16 bit colour (32000 colours) is not a luxury but essential.

From our experiences we can say that a movie with the size of 320*240 pixel's (a quarter of the screen) can be played with frame rate of 10-15 frames per second on a Mac IIfx. This is done with software only and played from a hard disk. This means that it can also be done using any mid and high range Macintosh (Centris and Quadra line). We have no experiences with a LC III, but we think it will not achieve this performance. And of course if you choose a smaller image size you can use a slower Mac or get more frames per second.

To achieve good results it is necessary to use high quality video material. High quality video material has less noise in the image and therefore less unneeded work in playing back this noise. If there is much difference between two frames, playback frame rate will drop. So a movie where a large part of the image is changing will give a slower playback frame rate.

Most of the Macs (Mac IIs and Mac LCs) in our faculty are to slow to display reasonable size movies and can't display enough colours. An image size of perhaps 200*150 pixel's will play fast enough, but for most purposes the 256 colours the computers can display are not enough. We suspect the are the same applies for the IBM-PCs with QuickTime for Windows or Video for Windows.

Storage mediums
The playback performance of QuickTime depends also on the storage medium used. The faster the storage medium is, the better the playback performance is. It is better to use a storage medium that has a faster data transfer rate then actually needed. The higher transfer rate gives the Mac more time to decompress the movie. This means that a hard disk is better storage medium then an optical disc or a CD-ROM. Optical discs and CD-ROMs can very good be used as storage medium but you will get a lower quality movie then could be expected based on the data transfer rate of the storage medium.

Recording experiences
During our work with QuickTime, we have experienced that you need a lot of disk space during the creating and editing of the movies. Compressing a movie is a lot of work for the computer, we found times of one hour or more computing time for one minute video. You need a very fast computer for making movies. QuickTime movies are, despite the compression, large files something like 10 MB per minute video.

Recording a movie in slow motion is a possibility, but you need a video recorder capable of playing perfect slow motion. That type of video recorder is very expensive, you are talking about professional equipment.

Examples

By using QuickTime you get a lot more possibilities than with traditional video equipment (laser disk player or video recorder). In a limited way you can compose your movie runtime, from different parts from one or more movies.

An interesting example that was showed, was a kind of simulation where you stood on top of the Golden Gate bridge (over the Bay of San Francisco). You could move the camera in every direction you wanted. The base of this example was a QuickTime movie containing camera shots for every possible direction. Depending on the next camera direction, the corresponding frame number was calculated and shown. Thus giving you the illusion of looking in every direction you wanted.

Conclusions

QuickTime for Macintosh as a software only solution can be good used with certain restrictions.

- A quarter screen size;
- 10-15 frames per second;
- Fast enough Mac capable of 16 bit colour (32000 colours) display (Centris and Quadra line);
- High quality video material;
- Steady image.

And if you can not live with these restrictions, you can buy additional hardware to achieve a better result. More frames per second, full screen size video, and this all even on a slower Macintosh like the Mac II.

In the nearby future there will be Macintoshes with additional hardware for handling multimedia standard build in. These computers will not only have video and sound outputs, as today's computers have, but also video and sound inputs.

References

Adobe Systems Inc. (1992), Adobe Premiere™: User Guide, Adobe Systems Inc., Mountain View, USA.

Apple Computer, Inc. (1992), QuickTime for Windows Programmer's Guide, Apple Computer, Inc., Cupertino, USA.

Apple Computer, Inc. (1993), 15 Steps to Better Movies, Apple Computer, Inc., Cupertino, USA.

Apple Computer, Inc. (1993,2), Inside Macintosh: QuickTime, Adison-Wesley Publishing Company, Amsterdam, the Netherlands.

Conclusions

Ivan Stanchev, Jan Schoenmaker

This report is deliberately built up around instructional visualisation and not upon multi media. Of course there is a close relation between the two, but in general when talking about multi media , we mean only the technology of storing , retrieving and presenting text, data, graphics, animations, audio and video. Our focus is more on concepts of visualisation , where to use it and how to design it.

We will possibly extend the scope in the near future towards virtual reality. Virtual reality allows one not only to perceive a pseudo real world as with multi media, but also to act upon it to a far more realistic level than with the possibilities of interaction which we have available with our regular computer technology. They are restricted to operating different input devices like for instance mouse and touch screen which are of course 'artificial' devices of action compared to direct manipulation by hands, feet or head.

Generally speaking our conclusions are twofold regarding future research and development:

Focus on conceptual aspects and types of applications, rather than on multi media technology
The focus in multi media should be on the concepts of instructional visualisation and on the processes of what to use it for like for instance instruction, exploratory learning or searching for information. Theories of educational and cognitive psychology in the area of visualisation have to be worked out and application domains have to be explored, rather than focussing on the more or less autonomous development of technology.

Focus on integrated and empirical approach, rather than on isolated theoretical research
Research, development and practical application and evaluation should be closely related. Empirical oriented projects should be prioritized, in which different variables can be studied in practice. One should go for an approach in which reference models and guidelines, derived from theory and experience, form the basis of design and development and in which evaluation in practice should lead to adapting a research and design and development approach. Such an emphasis leads to taking into account economic, organisational, technical and cultural asepcts in research and development. This empirical approach might lead to faster progress in this area than an isolated approach of studying only certain factors.

On a more detailed level we come to the following conclusions regarding concepts on visualisation, design and development and implementation:

Broadening the spectrum of applicability
By using visualisation not only cognitive skills can be developed, but also - to a certain degree - more affective skills like learning how to communicate, how to negociate, how to sell. Besides, using a rich, visualisation oriented environment also seems to motivate people. One could see this increased motivation as a basis for acquiring cognitive and affective skills, but one might also see the development of motivation as a goal in itself. This is for instance

relevant in business situations, where one wants to communicate for instance the mission and vision of the compancy, but with the explicit goal of increasing motivation or incentive. This process can go hand in hand with regular development of cognitive and affective skills. So we could say that with multi media the spectrum of applicability is broadened.

Choosing the right technological ambition level

The final goal of all research and development is that products will be used. Given fast changes in technology and the long R&D cycle and process of product implementation, there is a danger that reseachers and developers are running behind the technology. Although a product might still be quite good, one has to take into account the - often subjective - and changing acceptance and tolerance of the users. Think for instance about the shift from black-white to colour television. So, together with a strong focus on conceptual and design aspects, also a smart strategy has to be followed in terms of production and implementation. One should check that products really will be used before they are technologically outdated and possibly not being accepted by users anymore. Of course the other point is the danger of jumping to fast in new technology. And although research has to be done, one should not uncritically embrace technological developments as useful in themselves. For instance, hypermedia - making use of the hot spot concept - was there before anyone had really experimented and evaluated its value. Also with virtual reality there is the danger of letting technological developments lead the way.

Focus on content design, being of a combined creative and industrial nature

With multi media, expertise in graphical design and audio-video production becomes important. However, this should not be seen as an isolated process. It has to be integrated with the interaction oriented design of computer based training. This demands for good methods and training of people.

The design process, especially of the combined interaction / multi media presentation modes, is also a creative process as well as an industrial process. It is industrial because intermediate products, guidelines and standards and roles of people can be structured on beforehand. However, within the context of these pre-defined activities and roles creativity is needed. Especially making things visible is a creative process. So, design methods should allow and encourage people to be creative. New technology in itself does not mean or guarantee more creativity on beforehand. Even with textual based systems one can still be creative in order to develop an acceptable solution within the given context.

The use of visualisation in tools: interactivity and integration

In our definition of multi media we not only have the presentation side of it. We add interaction as a relevant dimension. It is the combination of multi media presentation and interaction which brings the added value. Interaction may mean for instance two way interaction like questioning and answering as in training. But interaction means also a mainly one way process of storage, retrieval and navigation as in a point of information. In developing tools it is the combination of interactivity and visual support which can lead to better quality tools.

Integration of different tools and applications is becoming more and more common. For instance the linking of a spreadsheet (as an object) in a text. However, integration in terms of exchanging data, encapsulating objects and using parts of the functionality of another application are no easy to understand activities. Using visualisation in order to support these integration processes in design- and development might lead to higher quality tools.

Appendix

Andersen Consulting - ECC
P.O. Box 3881
7500 DW Enschede
The Netherlands
phone: +31.53 333367
fax: +31.53.337825

Drs. A.H. Bergers
Ir. J.L. Evers
Mevr. Drs M.M. van den Meiracker
Ir. D.E. Nienhuis
Drs. J.M. Schoenmaker
Drs. M. Vegting

University of Twente
Faculty of Educational Science and Technology
P.O. Box 217
7500 AE Enschede
The Netherlands
phone: +31.53.893611
fax +31.53.356531

A.M. Berloth
Dr. P.A.M. Kommers
Prof. dr. J.C.M.M. Moonen
J. Sikken, M.Sc.
A.F.J. Rhemrev
Prof. dr. I. Stanchev
Dr. ir. P.W. Verhagen
Drs. W.J. Zwart

faculty of

EDUCATIONAL SCIENCE AND TECHNOLOGY

A publication by
The Faculty of Educational Science and Technology of the University of Twente
P.O. Box 2[illegible]
7500 AE Enschede
The Netherlands

BEST COPY AVAILABLE